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# GRASSLAND

*A Paper read on June* 14, 1921, *before the*
*Plough Club, School of Rural Economy*
*University of Oxford*

by

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OXFORD
PRINTED AT THE UNIVERSITY PRESS
BY FREDERICK HALL PRINTER TO THE UNIVERSITY

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# GRASSLAND

MR. PRESIDENT AND GENTLEMEN,

It was with considerable diffidence that I accepted the invitation to address your Club to-night; for I fear it is very like carrying an inferior class of coals to Newcastle to talk grassland to an audience so intimately associated with Professor Somerville. The name of your Club has, however, inspired me with courage, and it is perhaps not inappropriate to read a paper before the Plough Club dealing with grass, not from the point of view of permanent grass, but rather to consider in a little detail the possibilities of grass as a crop, as a rotation crop demanding no less than wheat or roots the continued activity of the plough.

I take it that from a national point of view we are all agreed that it is desirable to maintain as large an area of these islands as possible under rotation husbandry. Whether this can be made an economic possibility must in the last resort depend upon the character of the rotation; that is to say, it is, at all events, not the part of a progressive man or of a scientific man to assume that rotation farming is unprofitable, even under apparently the most unfavourable conditions, because of examples he may see before him, but rather is it his part to endeavour to investigate the matter and to formulate a system of arable or quasi-arable farming that will be profit-bearing despite the cost of labour and despite adverse conditions of soil and climate.

If we consider the high rainfall areas—the West of England and Wales—and areas of heavy soil—in short, milk and cattle-rearing Britain, we find that grass takes a prominent place in the scheme of agriculture. It requires no imagination, moreover, to suppose that were it a fact, and a generally accepted fact, that rotation grass was altogether more productive of milk, bone, and flesh than permanent grass, that this fact, properly understood, would be a greater financial inducement to the farmer to keep the plough active than a world of guaranteed prices for cereals. It behoves us then to inquire, firstly, as to the relative productivity of permanent grass and temporary grass; secondly, to endeavour to ascertain whether temporary grass is at present established and maintained in a manner likely to give the best possible results or whether the whole procedure as to the management of temporary grass might not be fundamentally altered and improved; and, finally, to consider the possibility of an economic rotation with grass as the pivotal crop.

I must at the outset say that I cannot even begin to approach my subject with any degree of finality. But if not informing, I hope at least my paper may be suggestive, and of some little assistance to those who are both able and willing, or, shall I add? daring enough to explore amongst the quicksands of unorthodox rotations.

### *To Compare the Productivity of Permanent with Temporary Grass.*

Unfortunately there is very little exact data available to enable one to gauge the comparative productivity of permanent and temporary grass. Sir Thomas Middleton has shown how varied is the quality of our permanent pasture, and it has to be admitted, despite the undoubted excellence of the best permanent grass, that the area of first-rate grazing land represents but a comparatively small percentage of the total permanent pastures of the country. It is true, of course, that thousands of acres have been, and that many thousands of acres more could be, improved to twice or three times their former productivity by proper manurial treatments and better systems of stocking, the point at issue being, in the case of medium or poor pastures, whether they can ever be improved up to the standard of a high-class ley on the same soil. Practical opinion holds that, under equal conditions of soil and climate permanent grass, especially slagged permanent grass, carries stock better than temporary, a view, however, that, in some districts at all events, is weakening since wild white clover has come to be extensively used, and it has been found possible rapidly to establish a dense sward on re-seeded fields.

The fundamental difference between the sward on an ordinary four- to six-year ley and on an old permanent pasture is the greater density of the latter. A large series of botanical analysis made by my colleague, Mr. Jenkin, on plots improved by dressings with slag and other phosphatic dressings have shown that the most striking feature of the improvement is the increased density—a density not only occasioned by an increased white clover population, but brought about also by a great addition to the number of tillers of grass per unit of area.

Now the leafiness of a plant is chiefly a function of the number of tillers it bears, and of the proportion of barren to flowering tillers; a dense sward consists of a dense network of grass tillers and therefore produces an abundance of root leaves and affords plentiful grazing. It must be admitted at once that leys sown down with inadequate mixtures cannot compare in density with permanent grass, but it must be admitted also that popular opinion as to the grazing value of leys is not in the main derived from an experience of excellent leys with wild white clover as an ingredient in the mixture.

On poor soils the herbage of fields improved by slag often remains decidedly weedy and consists of excessive amounts of bent, whilst improvement by manurial dressings is often slow and disappointing, especially when a dense matted sward has been allowed to develop, more particularly on soils deficient in lime, whilst even good permanent pastures usually contain considerable amounts of buttercups and other weeds. The most serious defect of permanent grass, even of good permanent grass, is the comparative shortness of the grazing season; indeed, this is the outstanding limiting factor to the productivity of permanent grass districts. Temporary grass—at least an area under a sequence of temporary leys of different ages—undoubtedly affords a longer grazing season, and I shall show hereafter that there are good reasons for thinking that by somewhat altered management the grazing season might be lengthened very considerably. Failing exact quantitative data I have only been able to review, and that briefly, the characteristic features of permanent and temporary sward; it would probably be near the mark to say that on really good pasture soils the permanent swards are to-day, and possibly always will be, the most productive, whilst on medium and poor soils the temporary are capable, with the seeds at present available, of being made at least as productive, and in most cases considerably more so, than the permanent. I shall allude to the case of the poorer soils in greater detail when I discuss management, and evidence suggests that under proper management the temporary swards would average out the least weedy.

When we come to contrast meadow hay with seeds and temporary hay a certain amount of quantitative data is available. The agricultural statistics, for instance, show that for England and Wales as a whole seeds hay gives, on the average, about 6 cwt. per acre more bulk than meadow hay. The disparity is greatest in counties where the leys are usually not left down for more than one year; but in such counties as Derby, Westmorland, Cardigan, Radnor and Brecon, where the leys are left down for three to six years, the seeds or ley still averages 5 cwt. per acre more than the meadow hay.

Reports of trials at agricultural stations give more detailed information, although I know of no prolonged experiment having been devised with the avowed aim of comparing the yields from meadows and temporary grass under exactly similar conditions.

At Cockle Park meadow land under alternate artificials and dung has averaged 41 cwt. of hay per annum over a twenty-three year period and under artificials alone 30 cwt. for a like period.

Well-balanced seeds mixtures, including an adequate amount of Cocksfoot and wild white clover under basic slag, have averaged 46 cwt. per acre per annum for three-year periods, and 33 cwt. over a twelve-year period under soil conditions apparently similar to the meadows.

At Saxmundham the best mixture under slag has for an eight-year period averaged almost precisely a similar yield to the best manured meadow land.

In Aberdeenshire 40 to 49 cwt. per acre per annum has been averaged for three-year periods. Thus it would appear that leys of three years' duration, cut annually, will give yields well in excess of meadow hay for that period, and from trials I have conducted myself in Wales, and from what I have seen of good leys in general in England, I am inclined to think that under most conditions of soil and manuring a five-year period ley will usually produce more bulk per acre per annum than meadow hay. Meadow hay is usually excessively weedy, and this is true of even excellent meadows which may consist of 15 to 30 per cent. of weeds. Leys, well put down and well managed, should be relatively free from weeds for at least a five-year period, a fact which must surely count heavily in favour of ley hays. The following figures, obtained from analysis which I made on the Saxmundham plots when eight years down, illustrate the relative weediness of meadow and ley hay:

| | | | |
|---|---|---|---|
| Permanent Meadows, | Unmanured . | 180 | Weediness in a scale of marks. |
| „ „ | Slagged . | 120 | |
| Elliot Mixture | „ . | 25 | |
| Other Mixtures | „ . | 90 | |

The temporary ley undoubtedly affords a ready means of adding to the hay supplies of a farm, which is a matter of some economic importance when it is realized that heavy crops of ley hay can be harvested off comparatively poor soils, and thus, by extending the area under leys, it would often be possible, without upsetting the balance of the farm, to convert fields now devoted to the production of poor meadow hay into very tolerable grazing pastures.

I have alluded in some detail to this aspect of grassland management in a recent article in the *Journal of the Ministry of Agriculture* and will not dwell upon it further here.

## *The Management of Temporary Grass, and Consideration of the Direction in which Improvement may be possible.*

It will be convenient to divide this aspect of my subject as follows:

1. Nowaday management, using mixtures as the basis for forming leys.
2. To consider whether single species might not in certain circumstances be better than mixtures.
3. To inquire as to the scope of improving herbage plants and postulating improved herbage plants to endeavour to estimate the influence of such improved strains on the economic status of the ley.

In speaking of temporary grass one presupposes the use of well-balanced mixtures. It must, for instance, now be taken as proved that excessive sowings of Rye Grasses are a mistake, that Cocksfoot and Timothy in fair amount should find a place in most mixtures. Wild white clover should no longer be regarded as merely an interesting experimental plant, but with Late-flowering Red Clover should constitute the bed-rock ingredients of leys for over two years' duration.

In regard to the general management of leys on present-day lines, there are two points in particular that seem to need emphasis: the one is the question of nurse crop, and the other the question of the preparation of the ground; and these are the only two points upon which I shall touch in this connexion.

With regard to nurse crop, a cereal nurse labours under two serious disadvantages: it restricts the season available for sowing the seeds, makes it difficult to prepare a clean seed bed, and it involves a serious risk of spoiling the ley at the outset if the corn becomes badly lodged.

It is probable that if the value of a good ley were better appreciated the farmer would be willing to compromise to some extent between his covering crop and his ley, especially should this be done when leys are left down for three to four or five years. We conducted an experiment last year, using the early and well-standing short-strawed American Sixty Day Oat as a nurse. We sowed a full seeds mixture (20 lb.), three-quarter mixture, half mixture, and quarter mixture, under a full 3,000,000 grain per acre nurse sowing; three-quarter nurse sowing, half and quarter nurse sowing. We got quite a good grain yield from the three-quarter sowing, an appreciable yield from the half, and from the quarter we harvested a good crop of oat plus seeds hay in September. Under the three-quarter and half grain seeding we got as good, or rather better, a take from the 15 lb. of seed as from the 20 lb., and nearly as good from the 10 lb. If good mixtures with wild white clover are used this saying in seed counts for a good bit. An early maturing cereal and slightly tillering cereal does not, of course, compete so strenously or for so long with developing seeds as does a later and more heavily tillering variety. The best results from seeding are, however, often to be obtained under rape; this allows of a prolonged period to clean the land, and makes it possible to choose a showery period for sowing the seeds, June, July and early August being excellent months to sow seeds.

Seeds mixtures are invariably sown at the end of the rotation after a cleaning crop; seeds can, however, be sown to excellent advantage as the first crop in a rotation on a newly broken sward. I have said that on poor land, poor swards are frequently improved but slowly by slag or other dressings, especially on soils deficient in lime with a densely matted sward.

If such swards are broken in winter or early spring, limed and slagged and re-sown in May, June or July under rape first-class takes and excellent new swards may be expected to result. This procedure constitutes the Rape Pasture of Wibberley and is a really good plan of improving inferior grazing.

On many poor soils the permanent grass can never be good, and a farm run on a sequence of four- to five-year leys will undoubtedly produce more grass keep than the same area in permanent sward. During the War my friend Mr. Bligh in Breconshire tackled a large area on the above lines, sometimes sowing out under rape and sometimes under a first and only corn crop, with the result that to-day the herbage on his farm as a whole is more productive and earlier and his hay is more bulky and of much better quality than on slagged permanent fields on his own or his neighbours' adjoining lands. It must be borne in mind that with a sequence of leys there will always be a certain proportion of new ones which, with careful grazing, afford a considerable measure of late autumn keep and which start into growth early in the spring.

In connexion with sowing out on a newly broken old sward, there is one important precaution that should always be taken, namely, to ascertain whether the soil is replete with charlock or other buried weed seeds, and in this connexion it is nice to find a very pretty research having a practical application. It would be an easy matter for a farmer to follow Dr. Brenchly's simple procedure, and if charlock was a danger to sow out late under rape and destroy all seedlings before sowing the seeds.

### *Mixtures versus Single Species.*

I shall now depart from the canons of ordinary management and venture some speculative suggestions based on the results of small scale field and garden trials, speculations which seem to me to indicate lines for experimentation on a large scale.

In connexion with our work on herbage plants, we, at Aberystwyth, have been struck by four outstanding phenomena. First, the undoubted incompatibility of certain species for growth with each other, species which tend in a mixture mutually to crowd each other out; thus Rye Grass and Cocksfoot are highly incompatible, Tall Oat Grass and Cocksfoot are incompatible, as are Late-flowering Red Clover and Alsike Clover.

This phenomenon has been tacitly recognized in recent years, with the result that progressive farmers are using simpler mixtures for three- to five-year leys. Mr. Stratton, in Monmouthshire, has been obtaining excellent results with

Cocksfoot and Alsike only, in Cardiganshire we have had highly satisfactory results with Cocksfoot and Late-flowering Red Clover only, and Professor Gilchrist's mixtures are of the relating simple type.

Our herbage trials have involved sowing numerous comparative plots of different species pure—we have noted that these cover the ground perfectly well, and that the several species have very different growing periods—and that stock appear to relish one species at one date and another at a different date. Thus Tall Oat Grass, although rather a late grass to flower, is one of the earliest to throw up a bulk of herbage early in the spring.

During March and April the Tall Oat plots were grazed to the ground by sheep in preference to almost everything else; during April Cocksfoot was preferred by sheep to Perennial Rye Grass, whilst Italian Rye Grass was liked even better than Cocksfoot. Let me add that Tall Oat Grass, for instance, does not compete well in mixtures with other grasses, and if included in mixtures tends to be grazed to death in March and April and soon disappears. The third fact we have noted is the remarkable influence of a previous year's management on the amount of keep thrown up by certain species, in particular during the early spring of the following year; this applies to quite a remarkable extent to Cocksfoot, a grass which is of pre-eminent value as affording keep when so badly wanted in February, March, and April. The position is explained by reference to Table I.

We have not yet collected exhaustive data on the same lines for other species, but the matter appears to be in the same direction, although not to so marked an extent. The fourth point of interest is one that first struck me when visiting Svalöf in Sweden and Tystofte in Denmark. At these stations grasses are grown singly in spaced rows for investigation and in spaced drills for seed production. The productivity of grasses so grown is truly remarkable, and in our own trials we have been similarly struck by the productivity of grasses when grown in drills (about 1 ft. 6 in. to 2 ft. 6 in. apart) and also by the earliness at which growth in earnest commences in the spring. The above facts cannot be without economic significance, the point being whether present-day management involving the use of mixtures is the best plan of getting the maximum out of herbage plants. It seems to me that since different herbage plants are probably quite as different as say Wheat from Oats, that they would repay culture as pure crops on a plan designed to get the most out of each. Take the all-important question of adding to the length of the grazing season—March and April grazing.

Suppose a field was sown, in say acre-breadth, of Tall Oat and Cocksfoot, and the grazing regulated by proper fencing, the most could be made of the earliness of these grasses, and by moving the stock across the field they would not be allowed to graze any portion to death. So for each month in the year it would probably be found that a single species or a combination of one or two species would give the maximum result, the management would aim at arranging time of sowing, method of sowing (perhaps sowing in lines), and methods of grazing to get the very best out of the correct species for each calendar month.

Here then we would have a really scientific intensive and absorbingly interesting method of grass farming. Complicated mixtures, like terribly mixed plantations, are nothing but a shot at a venture. Simple mixtures pre-suppose a certain knowledge of the relevant facts, pure cultures would involve a profound knowledge of the requirements of stock and of the characteristics of herbage plants. Knowledge is power, and I venture to think that trials designed with a view to test out the pure culture idea of grass production and management afford a line of investigation that might well reward the most ardent of agricultural enthusiasts.

### *The Possibilities of Improved Herbage Plants.*

But little attention has been paid in this country to the improvement of herbage plants, although as long ago as 1852 Peter Lawson & Son of Edinburgh in *Vegetable Products of Scotland* described several different strains of Rye Grass and a few of Cocksfoot which were apparently available in those times. To-day we have only left some of the names such as Devonshire Eavers and Pacey's Rye Grass, which now seem to be but trade designations and do not denote any very special strains. It is not perhaps generally realized how devious are the sources of origin of the seed of our herbage plants. True it is that most of the Rye Grass seed is grown in Ireland, Ayrshire, and the Fens, but we even import some Rye Grass from Denmark. Most of the Crested Dogstail seed comes from Ireland, we import great quantities of Red Clover from Chile, Canada, United States of America, and Europe, and we import nearly all our Cocksfoot, Tall Oat Grass, Rough Stalked Meadow Grass, and most of our Timothy.

The source of origin of seed is a matter of great importance, but except in the case of Red Clover it is a question that has hardly been subjected to critical trial in this country, and yet with the example of Wild White Clover before us it would appear to be desirable to test out all the sources of origin for the different species against indigenous wild seed collected at home.

Trials of this sort have been the basis of the plant-breeding work on herbage plants at Svalöf in Sweden and at Tystofte in Denmark. At Aberystwyth we are following the Scandinavian procedure and have started our investigations by conducting a large series of critical nationality trials. Our results with Red Clover confirm those conducted by Findlay in Scotland, and some years ago by Smith in Leeds, and seem to show conclusively that Late-flowering Red Clover persists into a second year better than other strains, and that English-grown strains are better and more persistent than imported seed. We have found, moreover, that two local strains, i.e. Cornish Marl Clover from the Wadebridge district and the best strains of Montgomery Clover, bear certain resemblances to Wild Red Clovers but are late to flower and much more bulky, and, as far as we can say at present, appear to be long persisting. Our results confirm those obtained at Svalöf and Tystofte, which indicate that Italian Red Clover is a poor lank plant, a poor cropper, and apparently in Scandinavia and Wales, and I should imagine in Britain generally, well-nigh worthless.

With Cocksfoot we have found, as at Tystofte, the French seed gives very early flowering and stemy plants with the poorest possible ability for stooling and the production of aftermath. Danish and American seed gives plants fairly similar to each other, but the evidence already before us suggests that certain indigenous strains will prove to be more bulky. They have already proved themselves to be more leafy, to have a much better ability for stooling and for new growth after repeated cutting.

It is a remarkable fact that a comparison of indigenous plants, and of strains long grown in this country, with those derived from imported lots, for Red Clover, Cocksfoot, Tall Oat Grass, and Timothy, reveal a phenomenon common to all, to wit, that the native plants are far more leafy, and produce altogether more tillers than the foreign. The extreme and average figures in Table II clearly show the marked difference in the matter of tillering capacity. I have already alluded to the importance of density, and density which is the external manifestation of a capacity for tillering would matter just as much for plants grown pure or in lines, for it means the continuous production of root leaves. I have not figures available at present for the comparative leafiness of the several species except in the case of Cocksfoot, which are shown in Table III. A more critical investigation reveals the fact that it is not only in the gross number of tillers that there is a marked difference, but that the indigenous forms produce a far greater proportion of barren tillers. Thus some of the French Cocksfoot produce practically only flowering tillers, whilst some of the indigenous produce considerably over half their number in barren tillers, whilst occasional plants are to be met with which produce but one or two inflorescences during the first season. Another important difference is that some forms, when growth starts in the spring, produce an almost equal development of flowering and barren tillers. These forms of necessity produce heavy crops of leafy hay: other forms, although in the end producing numerous barren tillers, only develop these later in the season as a basal tuft below the flowering tillers.

It appears from our nationality trials that a great number of forms are to be found within every nationality, and that the nationalities chiefly differ from each other by the different proportions in which the various forms predominate. With perennial Rye Grass the forms are particularly varied and mixed, which makes comparison between the nationalities as such almost worthless ; but it seems probable that some of our indigenous forms, if not producing most tillers, none the less produce the highest proportion of barren tillers.

The trials as a whole have moreover shown that on the average the indigenous forms of all the species except Red Clover tend to flower later than the imported, some of the Wild Cocksfoot flowering from ten to nearly twenty days later than the commercial.

The facts I have narrated as to leafiness and production of tillers, especially barren tillers which hold good for so many species, can I think be explained in general terms as follows:

Over 150 years ago, when artificial grass first became a feature of agricultural practice, the seed was of course collected from wild grasses very largely in Germany. As the demand became greater the more important species were grown specially for seed. People collecting grass seed for sale would not be likely to gather it from meadows when the species would be very mixed, but would pluck it from coppices, hedges, and waste places, where individual species are often found in large masses together. The forms capable of colonizing such habitats would be more dependent on abundant and early seed production than on density, and would not be likely to have the same stooling capacity as those forms which are the best able to establish themselves on permanent grass lands. When grasses are grown for seed they are seldom left down for more than two years. Thus the tendency ever since grass seed became a commercial commodity would seem to have been to collect and then grow on a plan which has amounted to selection, for seed production as such, for a ready capacity to produce flowering tillers, no thought has been given to the characters which make herbage plants valuable—leafiness and stooling capacity—and unwittingly for the past fifty and more years a fairly rigorous selection has undoubtedly been exercised in favour of lanky, short-lived, and seed-producing strains.

From the above brief review, and bearing in mind what has been done at Svalöf and Tystofte in producing improved strains of Cocksfoot, Rye Grass, and Timothy, and in America with reference to Timothy, there cannot be the least doubt that it is a possible thing to breed special purpose strains of improved herbage plants, I say special purpose strains, because a hay grass is one thing and a pasture grass is another, because I believe a March and April strain to be a different thing to an October and November strain. If then improved and special purpose strains are a possibility, this must react on the economic value of the temporary ley. Already Wild White Clover has made it possible to eliminate the lean period—the period from the second or third to the fourth or fifth year, the period during which many of the sown species will have died out and before unsown desirable indigenous plants has established themselves.

When it is possible to obtain what is equivalent to a natural permanent sward almost immediately by sowing strains with a great stooling capacity, the only tangible objection to temporary grass will have disappeared, and then by a well-thought-out system of special purpose temporary leys the farmer has it in his power to add to his hay supplies and greatly lengthen his grazing season.

### *The Rotation with Grass as a Pivotal Crop.*

In conclusion I must briefly allude to the relationship which the temporary ley should bear to the rotation as a whole.

The idea of a stock farmer's rotation is no new thing. The work of Professor Wibberley in Ireland, and of Mr. Brown at Harper Adams, has, for instance, aroused considerable interest in arable dairy farming, and it is evident that grass management will in future have to be reviewed in the light of the heavy crops of forage hay that can be obtained from combinations of cereals with peas and other pulses and with vetches, and in the light of the early spring grazing afforded by the proper rotating of Kales and other crucifers. Such rotations are, however, ultra arable, for the crops suffer from the defect that they are chiefly annual or biennial, and that many of them at least are not of the graze and graze again, or cut and cut again type, and therefore on many farms, partly in order to keep down labour, are likely only to be compatible with a certain acreage of permanent grass. The temporary ley taken over at the whole reasonably ploughable area of a farm, apart altogether from the general character of the farming, carries with it certain important advantages, namely, it maintains the fertility of the farm, provided the leys are broken while the sward is still excellent and full of white clover; it maintains the whole farm in a ploughable condition; it tends, to some extent at all events, to solve the problem of the idle horse, for swards can often be ploughed when it is quite impossible to work the teams on plough land. In my experience wire worm is not often serious after three- to five-year leys. Farming with the ley as the pivotal crop does not necessarily mean intensive arable farming, for a field when broken can quite nicely be put down with a first and only cereal crop. It means, however, as I have said before, more hay off less land; in many cases more, and in most cases earlier grazing. So that even if the gross keep off a farm, the grass of which is derived from leys, is not greater than that from a farm partly in permanent grass and partly under a four-course rotation, the ley still carries gains in the direction of fertility and diminution of idle horse hours, whilst in connexion with arable dairy farming the proper use of the temporary ley must constitute an economic factor of the greatest importance.

When we consider the extent to which the temporary ley already figures in the rotation in certain districts, and when it is realized what scope there undoubtedly is for improving herbage plants and bettering the scheme of management of temporary grass considered as a crop, one cannot help wondering whether permanent grass is in fact so sacred as it is universally held to be, and whether the next great advance in agricultural practice will not be associated, as all advances have been associated, with further inroads on the area under permanent grass. The farmer will never, I think, sign the death-warrant of grass, but the culminating point in agricultural development will only be reached, and can only be reached, when grass is so well understood that it will pay better to grow it as a crop than to watch it grow as permanent grass. In this connexion it must always be remembered that the great advances associated with Townshend and the Turnip were also associated with the rotation ley, the first beginnings of the really self-sufficient rotation. In my humble opinion, as long as permanent grass dominates our agricultural outlook there can be no real progress. This was clearly shown by the tenacity with which people clung on to their permanent grass during the War, and, be it noted, still cling to it.

The nation's agricultural problem would be solved for ever if permanent grass could only be made unpopular. It will be unpopular only when and as soon as temporary grass can be made to take its place and to give in conjunction with a rotation with grass perhaps the pivotal crop—a greater and more economic return. It is because I am so convinced on this point that I regard it as a special privilege to have had this opportunity of presenting my case before the Plough Club, for, paradoxical as it may appear, a profound knowledge of grass and the possibilities of grass will, I venture to think, add speed to the plough as nothing else will, and that profound knowledge can only be gained by a large body of trained and skilled investigators backed by an enthusiastic body of practical and fearless reformers.

I would like to say that much of the data I have drawn upon in the preparation of this paper has been supplied by my colleagues Mr. Jenkin and Captain Williams, to whom my best thanks are due.

TABLE I.—TO SHOW THE INFLUENCE OF A PREVIOUS YEAR'S TREATMENT ON THE EARLY SPRING PRODUCTIVITY OF COCKSFOOT.

| | *Beds cut but once during* 1920. | *Beds cut once for hay* (*in June*) *and cut seven times afterwards in* 1920. | *Beds cut once for hay* (*in May*) *and cut ten times afterwards in* 1920. |
|---|---|---|---|
| Produce, green in qrs. in February, 1921. | 344 | 160 | 94 |
| Produce, green in qrs. in April, 1921. | 433 | 157 | 100 |

TABLE II.—TO SHOW THE NUMBER OF BRANCHES OR TILLERS PRODUCED BY PLANTS ONE YEAR OLD IN THE CASE OF CERTAIN COMMERCIAL AND INDIGENOUS STRAINS OF GRASSES AND CLOVERS.

| *Species and Strain.* | *Greatest and least Number of branches or tillers.* | *Average Number of branches or tillers.* |
|---|---|---|
| RED CLOVER. | | |
| Montgomery strain | 212—55 | 150 |
| Cornish Marl | 138—116 | 125 |
| Canadian | — | 68 |
| English Late-flowering Red | 97—27 | 50 |
| Chilian | — | 30 |
| Italian | 40—16 | 27 |
| TIMOTHY. | | |
| Indigenous | 212—82 | 160 |
| Commercial | 120—46 | 70 |
| TALL OAT GRASS. | | |
| Indigenous | 212—43 | 130 |
| Commercial | 132—38 | 80 |
| COCKSFOOT. | | |
| Indigenous | 169—40 | 95 |
| Commercial | 131—16 | 60 |

TABLE III.—TO SHOW THE AVERAGE LEAFINESS OF THE HAY OF INDIGENOUS AND COMMERCIAL COCKSFOOT.

| *Nationality.* | *Percentage of leaf in Hay.* |
|---|---|
| Indigenous | 38 |
| U. S. A. | 24 |
| Danish | 25 |
| French | 23 |

# LAND RECLAMATION

*A paper read on May 17, 1921, before the*
*Plough Club, School of Rural Economy*
*University of Oxford*

by

Sir A. Daniel Hall, K.C.B., F.R.S.

OXFORD
PRINTED AT THE UNIVERSITY PRESS
BY FREDERICK HALL, PRINTER TO THE UNIVERSITY

# LAND RECLAMATION

THE question I have to bring before you is that of Land Reclamation, one which has been a source of considerable public debate for some years, and is often appealed to as a means of dealing with the unemployment problem. I should like to consider Land Reclamation first from a general standpoint, and afterwards its application to present conditions. Roughly speaking, by reclamation is meant that a good deal of waste and unemployed land, not carrying crops or cultivated in any way, is supposed to have potentialities in the way of production which might be developed. If, for instance, you go southward to the New Forest, or parts of Surrey, and across Berkshire, you come to a series of light sandy formations—the Bagshot Sands. On the whole this is a land not in cultivation—open heath, unenclosed land, plantations—at any rate, it is land not producing much, and yet among it some comparatively fertile land seems to exist, land that is being farmed and is producing food of some kind. You do not see the reason why cultivation should end sharply in a hedge, why there should be on one side a reasonable crop of barley or potatoes, and on the other side barren heath. Is it not possible to extend the margin of cultivation? Some authorities suppose hedges mark the limits of the fertile land, but this theory does not seem to fit in with any feasible theory of the distribution of the soil, and you are bound to assume that the beginning of the 'desert' is really the result of accidental or social causes and not natural ones. Again, in many parts of the country there are large areas of drowned land—boggy, wet pastures doing very little good and covered with rushes or peaty deposits, and yet showing in comparatively smaller areas some fertile soil. The whole subject of Land Reclamation deals with the attempt to convert these waste areas into such cultivated land as in many cases exists alongside them.

Firstly, what are the causes and the methods of treatment we can adopt? In one group of cases reclamation can be effected by purely mechanical means, e.g. the raising of an embankment in certain regions of the coast. In the estuaries of many rivers, notably the Wash, you see outside the cultivated land always a bank thrown up by human endeavour. Seaward of the bank there comes what is generally called the outmarsh, which is a grass, or a green vegetation-covered area, occasionally flooded by the higher tides, in the meantime affording useful sheep grazing, as a rule interspersed with drainage channels. Reclamation of this kind has been going on from prehistoric times—preserving the land from the natural incursions of the tide. This land is extremely valuable because the actual soil consists of beautifully tempered silts, washed down from other formations, mechanically and chemically constituted so as to form a very fertile soil. All this type of reclamation is a record of successive 'Innings' as they were called—for example in Romney Marsh, the first bank is said to be Roman, but may be pre-Roman. Other banks begin about 900 and continue in 1100, 1300, and so on, right down to the beginning of the nineteenth century, bit by bit winning the marsh from a tidal waste.

Another very similar form by mechanical means entirely, is the reclamation by drainage along certain river courses. The classical example is the Fen country—that stretch of land including parts of Norfolk, Cambridge, Huntingdon, and great part of Lincoln, right up to the Humber. The estuaries were all flooded, and and has been successfully won out of the marshes by artificial drainage; in a good many places it is now below the river level, and the water must be lifted artificially if the land is to remain fertile. There are many areas in the British Isles that are still undrained, and the land will remain water-logged until some one deals with it as the Fens were dealt with.

Then there is the chemical side of Land Reclamation. There is a large area of land practically heath or common waste, and in nineteen out of twenty cases these areas prove to have extraordinary light soil below—these areas are unfertile because the soil possesses very little natural richness. I have already mentioned the New Forest, which was not laid waste by King William but has always been waste, a great part of Surrey and Berkshire, the great heaths near Cambridge, through Suffolk and Norfolk, the so-called Brek and other land, which it has not been worth while to enclose because the crops it would carry were so poor. The soil, as a rule, consists almost purely of sand, sometimes comparatively coarse sand, and is chemically deficient in the soluble minerals. There is no lime, and very little potash, or phosphoric acid. If you want crops you must rectify this deficiency—it is a chemical problem—by growing leguminous plants to capture the nitrogen from the air and build up a vegetable soil by degrees. You can find certain occasional reclamations by squatters who were content to grow miserable crops, and who had no knowledge of the chemical methods of dealing with land, but who built up a soil from the débris of previous cropping, and by introducing manure little by little, but it was a slow and painful process. The squatters must have lived a miserable existence for generations before the soil became approximately fertile; and even to-day the soil is nearly always short of lime, potash, and phosphoric acid. During the last century, when chemical knowledge had advanced to the stage of being able to examine the soil, when fertilizers like basic slag provided a cheap source of phosphoric acid, and the German potash salts provided potash, it became possible to reclaim these heaths and barren sands. That work was not done in this country to any great extent, because though we know quite a lot of science, the great mass of the people do not believe in it at all. Neither the landowner nor the capitalist believed in science, and so we ignored these possibilities altogether; but in Germany and Belgium the reclamation of heath land was on a large scale and largely successful, many hundreds of thousands of acres being brought into a reasonably fertile and productive condition. Necessity had something to do with it, because a large portion of Germany is covered by this extremely light heath; they had to do something to make this land productive, as the old

German Empire depended for its existence, in the first instance, on developing an immense production of food. That is in brief outline the two types of reclamation; they are fundamentally either (1) mechanical, or (2) chemical.

We will now discuss these principles a little more in detail as regards the British Isles. Are there opportunities for either of these types of reclamation in the British Isles? Take first the mechanical enclosure by embankments. There are considerable areas for enclosures of this type; people who have had experience will tell you it is no good trying to bite off too much with a bank. If you risk getting a depth of more than four feet of water outside your bank it is likely to give way through the combination of pressure of water and wind, causing wave action upon the bank, and the margin of the Wash is full of examples of rash people who put down a bank in too deep water. As a general rule you must not take your bank beyond the grassy level, and in consequence, automatically, you never have more than about four feet of water plus the irregular wave-level as compared with the inland side. We know that with modern engineering you might perhaps do more than that now, by strengthening by reinforced concrete or some other method, and so get larger areas. Of course in Holland they have an age-long experience in this matter, and they embark upon big schemes —there is the great scheme for embanking the Zuyder Zee. Without doubt these Dutch engineers reckon it is feasible to put a bank almost across the Wash. But apart from the Wash, there are certain areas in the river estuaries which contain land suitable for 'Inning'. At the present time in the Wash I think there are about four thousand acres which could be taken in with perfect safety. In the estuaries of the Stour, the Ken, the Blackwater, and the Thames, there are certain areas, not often large, but considerable areas, and others again at the mouth of the Arun and the Adur; and further west Poole harbour; in Devonshire at the mouth of the Tamar and the Exe there is land ripe for 'Inning', and certain other estuarine lands up the western side in Lancashire, in the Morecombe Bay district, and in the Solway Firth.

Turning to another process, that of drainage, a very cursory examination of the country shows that there are considerable areas which want the water taking off by some artificial means, drainage or pumping, &c., in order to give the water opportunity to get away. For example, at the mouth of the river Dovey is the Borth Bog, which is all soaked land, drowned at high tide, which wants cutting off and an artificial pumping-station to take the water away. Closer home you get Otmoor, which I recommend you to explore. It is a piece of drowned land, almost every other hay crop is destroyed by wet in the process of making. The difficulty there is that the exit of the river Ray by Islip is shallow. Otmoor lies in a basin with a high ledge; that ledge ought to be cut through to let the water into the Cherwell, probably the Cherwell itself needs cutting a little deeper in the upper levels. There are many similar peaty areas in various parts of the country.

A third form of dealing with drowned land is practised chiefly on the banks of the Humber—the process known as 'warping'—where you generally shut in about 400 acres by a bank with suitable sluice gates leading to the tidal river. The tidal river water comes down thick and is let on the land at high tide by means of a canal. This is filled up to the brim and the water left there six or eighteen hours (one or two tides) and during this time of quiescence the sediment carried in the water is deposited on the land and the clear water run off, leaving behind the solid deposit. In that way a deposit is built on the lower level. Generally in about a year or two you can build up from 2 to even 4 feet of deposit upon the old surface. After cutting off the water of the canal you must allow time to consolidate and dry the deposit, and you then get some of the most beautifully tempered and richest land in the country, containing organic matter washed down from the higher levels. This 'warping' process still goes on to some extent in the Humber district, and there are openings for more of it.

In reclamation by chemical means there are a number of heath areas which have not being dealt with in the Eastern Counties, something like 200 square miles known as the Brek, a very light sandy soil—anything from 6 inches to 6 foot thick, lying upon a subsoil of chalk and extraordinarily barren. Newmarket Heath forms a portion of it: this brek area extends from Thetford to Sandringham. The country is extraordinarily waste and is chiefly given up to Scotch Firs and partridges. These heath areas form one of the toughest reclamation propositions; the rainfall is very low, only 20 to 22 inches per year, but even of that land there has been an experiment of value. In 1913 the Development Commissioners took over 200 acres covered with nothing but rough bracken and primaeval vegetation, and dealt with it on German lines—there is no other way. The first step was to dig up some of the chalk which was all underneath and spread it at the rate of about 6 tons to the acre, then work in basic slag at the rate of about 6 cwt. to the acre and an equal amount of crude potash salts. One must keep on putting on basic slag and potash salts every year. After the chalking a steam plough was put on to rip up the bracken and vegetation, and the first summer was spent in killing as much of the native weed as possible. There are two theories as to the further cultivation, and supporters of both. (1) Grow first a leguminous crop—lupins is the one chiefly used—plough it in when about 1 foot high and beginning to flower, and that builds up a soil by collecting humus and nitrogen from the atmosphere. (2) Buy nitrate of soda and start cropping straight away, oats, turnips, sometimes vetches for fodder, potatoes (a good crop for cleaning) out of artificial manure and be thankful if the soil will hold the crop in the ground. It was decided that we should work on the leguminous crop system, but as a matter of fact we did the other thing. The war came on, prices were rising, and our manager had no patience with slow methods. Of the 200 acres dealt with about 160 were taken in, the rest being left waste. The ploughing, putting on the chalk and basic slag was done in 1914, and the capital outlay was about £6 an acre. It would possibly be three times that to-day. By 1919 that area had been brought into such good cultivation that it actually grew 4½ quarters of wheat to the acre. Further it had not only paid its way but has paid for the capital charges. The sole condition is that you must go to the fundamental initial expense of getting the chalk into the land, the supply of phosphoric acid and potash, and then you must keep on manuring. You must give it a dose of basic slag or superphosphate every crop, and preferably tickle it up with nitrate of soda as well, but you must remember that it is extraordinary cheap land to work, being of the lightest possible description. You must sow very early and spend a good deal of time rolling the land down tight and then it is marvellous, with plenty of potash in the soil, how it will stand the drought and give a yield. Nothing is more striking than the contrast between the potash and non-potash fields on this kind of brek land.

As you come southward there is another type of very light, largely uncultivated, sandy land which can be reclaimed and has been reclaimed in patches. Of course Essex is the county of strong land; but coming to the Wealden area, Surrey, and Sussex, you have many areas which require first of all lime and secondly potash. On the Bagshot Sands farm after farm cannot grow crops because it is smothered with spurrey and brilliant with corn marigold, and yet it is a certain fact that if you put on chalk or lime you get rid of these weeds as a result of one good dressing of chalk. Going southward through Hampshire, into the New Forest, you get similar areas especially when you get into Dorsetshire itself, all about Wareham and the back of Bournemouth, which could be made fertile land if the chemical treatment were attended to.

There is another class of land to be dealt with in a somewhat similar fashion. Perhaps a number of Cornish moors affords the great example where, by a curious phenomenon, the heath vegetation looks as if it were full of water, but, when examined closely, underneath is found at 5 or 8 inches deep a hard pan layer of cemented particles which is continued all over the soil and gives the plant only a few inches to grow in, making an effectual barrier to drainage and the rise of sub-soil water. You cannot do anything until you break up the pan, both mechanically and by the introduction of lime.

There exist considerable areas of this land, some of which, as the local people know, can be reclaimed by bringing up the shelly sand from the beach—this land can be rapidly converted into fertile soil.

There is another type of land, in some ways most promising of all, exemplified in many parts of Dartmoor, Exmoor, Wales, a great part of Yorkshire from the Derwent northward, like the moors about Scarborough and Whitby, and again many of the low-lying moors of Scotland. This land is not like the heath land, some of it is comparatively strong land but it has not been under the plough, and because of the altitude or situation not likely to make arable land nor to respond to the plough land system, but you can get good pasture if you go the right way to work. The method adopted in Germany for this kind of land is to burn off the heather in the summer and then to break up the surface, not with the plough as it was found better to break the surface down with a series of disk harrows, gradually working up a small surface tilth perhaps not more than three or four inches deep, dress with some form of chalk or lime, potash and phosphoric acid, and sow grass and clover seed in the autumn, thus straight away establishing a pasture. The grass will soon get hold and grazing will rapidly convert the land into pasture, but you must work systematically, attending to the lime and phosphate deficiency. Indeed, in many areas where conditions are not at their worst, it does not require anything more than basic slag to win the land, therefore you get this kind of improvement effected at a minimum of cost.

I need not go further into details, but what I want to come to is this: some years ago I was engaged with Mr. Orwin on a considerable survey of possible openings for reclamation throughout the country: we tabulated the results and got a preliminary idea of how to get to work. None of these schemes is feasible to-day. Reclamation on a large scale is not a practicable proposal under present conditions, for the simple reason that the main factor in the cost is labour, which is double or treble the price it was in those days, yet the land that is the final product has at the most increased by 50 per cent. in value. It follows that a proposal that was on the limit of being economic seven or eight years ago is now impossible. For example, take embankments: in 1919 my Ministry was asked to take up this question of land reclamation as speedily as possible because a large amount of unemployment was expected, though these fears proved later to be groundless. All the schemes except one had to be scrapped, and only this one pushed right through. That was an embankment of some 300 to 400 acres of really ripe land on the Wash near Waynfleet. When completed, the cost within a few shillings, was £167 an acre, and the land will be worth in a couple of years, when it has had time to consolidate, about £40 an acre; that shows the economic value of these schemes, even when as in this case the scheme was thoroughly sound. Why did it cost this enormous sum? There are two reasons, because we took on unskilled (unemployed) men and wasted an enormous amount of time and labour in getting to work—in fact with the same men the bank cost three times as much per yard in the early stages than towards the finish when the men who could not work had been eliminated and the others had become habituated to the work. Then there was a great initial capital expenditure in housing the men for the work. Wage rates had got too high, and this is the factor which makes all large schemes of reclamation quite impossible at the present time, that the price of labour has risen out of all proportion to the value of land.

As to the other side of the picture, even if it be uneconomic might it not form a good outlet for unemployment? There are probably about two million men at the present time drawing unemployment allowances. Might it not be better for the State to turn these men on to land reclamation, uneconomic as it is, and so get something for the money? Even that hope I am afraid is illusory. It ought not to be so, but it does cost more to work with such men than if you left them absolutely idle drawing unemployment pay. Firstly, all these reclamation schemes are a considerable distance from normal centres of population, the shores of the Wash, the Cornish and Yorkshire moors, the Dorset heaths, and if you bring a number of men to do the work you have to put up hutting, make arrangements for bringing, housing, feeding them, &c., then there are left behind the wives and children who have to have allowances, so that it becomes an extraordinary expensive job. Then one must take into account the reluctance of the men themselves to go the distance. It may be true that a steel-worker from Sheffield does not want to work on the banks of the Wash, where there are no picture palaces, generally not even a public house, but to put it more fairly to the man we must recognize that his trade is steel-making and he wants to get back to it, but does not stand much chance of being taken on again if a chance offers and he is a hundred miles away. Another factor is the Trade Union rates of pay on a job of this kind—you have to pay to unskilled men navvies' rates for work which is not done in navvies' style. We need not be unfair to the men and say they do not work their best. But you cannot expect the rank and file of the industrial population to shovel dirt under the roughest possible conditions; they are not used to it, and therefore make a very bad job of it. It is not economic, even if from the £3 a week you have to pay you knock off the 28*s*. which they would be paid when idle; the remaining 32*s*. is far more than their work is worth, as they cannot do half a skilled man's work. More than that, they upset the whole agricultural population of the district. If you take a number of unemployed men to an agricultural district and have to pay Union rates, say £3 a week, when the rate for agricultural labourers is £2 6*s*., you will find a lot of agricultural labourers trying to get on to the unemployment lists with a view to coming on to your reclamation job. All the farmers are at once up in arms because you are drawing their men away. There is another side to it; you cannot throw a whole army at the job and do it quickly; you are limited by living accommodation and by physical conditions, you can only take, for example, so many men to the yard of bank. There is still another side: if this reclamation work is to be properly done it requires skilled rather than unskilled men; it is not, although it may look it, an unskilled man's job. If you are going to do it well and cheaply the condition is that you employ as much machinery as possible. If you put the job in the hands of a modern contractor accustomed to shifting soil, he will do it chiefly with machinery and much more efficiently than you can do it by hand. Take even the case of reclaiming a heath or moor. It is mainly a matter of ploughing. You cannot put on unemployed to plough, least of all with steam or tractor, which is what ought to be done in order to make a good job of it. You want skilled men for these reclamation jobs to a much larger extent than unemployed unskilled men.

You will think that all this is very pessimistic. I am an advocate of and believer in land reclamation, and perhaps you would like to know if there is any other side to the picture—I think there is in a limited way. There is a certain amount of land reclamation which, even under present conditions, can be done, but I certainly think it is a prime condition that such land reclamation as is done shall be carried out by the owner of the land, and not by the State or the municipal or local authority. The second condition is (really a consequence of the first) that it should be carried out with 'cheap' labour—I will explain what I mean by cheap labour. You cannot go straight into it at any season of the year and pay full labour rates. Let us consider the disadvantages. A lot of these schemes are so enormous that the State is the only body big enough to tackle them, but the real trouble is that the State has always a difficulty in getting a full day's work out of its employees. When compared with other people dealing with organized labour it is always at a disadvantage and drives a bad bargain, therefore when it comes to employing large numbers of men for temporary jobs it always does it very badly, and in that sense is a bad employer. The other difficulty is that of ownership. When you have done a piece of reclamation your return is to be obtained either by selling, farming, or renting the land. But no land in this country is state property, it is all privately owned and the owner may be quite willing for you to put in hand a reclamation scheme, but says that when you have done it the result must be his own property. The State can never drive a bargain which will secure to itself the value of the improvement: you are in the other man's power and he dictates the terms—we have no legislation to enable the State to take land at its own valuation. It must be bought at its potential value and the improvement is one of the elements connected with its potential value; the seller always includes in the price the improvement you are going to effect. Another question of ownership arises in that very often there are a great many owners of the land included in one scheme. Mr. Orwin investigated the title to Borth Bog, and if I remember rightly there were between 130 and 150 owners. It is not an easy business to arrive at an equitable settlement with ownership of that description, and usually the more uncultivated the land the more doubtful becomes the question of title. Again, an owner, and only an owner, can get his labour 'cheap'. I do not for a moment want him to beat down a man, or take advantage of conditions like unemployment in order to get sweated labour, but cheapness arises from using the labour at the right time. It is quite possible for a private owner to pay agricultural labour rates and not the navvy trade union rates which the Government would have to pay, and so save a good deal of cost. Then a man with a staff of his own can put them on to reclamation work when normal work is slack and so get cheap labour.

What kind of reclamation can be done? The most promising type is the moorland, which can be dealt with by a comparatively cheap process of cultivation to form a shallow soil before sowing. There may be also a little drainage, some bushes and stones to be removed, and then there is the cost of lime, seed, and manures. In certain cases the process is simpler still, as it is only necessary to get rid of the bushes and the bracken, to put on the basic slag, and keep the land well sheeped. In all parts of England on farm after farm you will see waste fields which are in this state of being partially bushed or brackened over. The sort of reclamation that will pay the owner and the farmer is to take such lands in hand. Often there are water courses to be cut out—the drainage problem is interlocked with the reclamation of waste fields. There is another sort of reclamation which can be done cheaply—woodland which has been cut down during the war and is now a mass of thistles, land which the owner does not intend to replant. What is to be done? If you stump it the cost is more than the land is worth. The County Agricultural Committees will be serving notices that they must not have these areas distributing thistles and every other kind of weed far and wide. I believe the only promising way of breaking in these areas cheaply is somehow or other to get sheep grazing on them, whereupon the timber will die and you may get a pasture. I think the only way, in many cases, is to get the land disk harrowed so as to cultivate a little bit of the top, sow wild white clover and get up a vegetation that will enable you to run sheep over these areas. It may not be a paying proposal for a time, but these lands cannot be allowed to go waste.

Then there is the question of hedges, which form a deplorably large fraction of the uncultivated English land. If you took a survey you would probably find but not far short of 10 per cent. of many farms is occupied by hedgerows and banks. These have to be grubbed and got rid of: modern cultivation demands bigger fields and longer runs for tractors and steamers. You must get the air and sun into the land more than you do. You must avoid the vermin which harbour in the hedges, and guard against the infection of both insect and fungoid pests. If you try to get hedges up by contract you will find it will not pay for the land recovered. There is a real reclamation possible on almost every estate, but it must be done by cheap labour, i.e. men out of due season when not doing other things. The Ministry of Agriculture has been experimenting with newer methods—with explosives and various kinds of machines, but human labour, aided sometimes by tractors, or steamers to tear hedges out, is the most economic way. The difficulty with drastic methods like explosives is that they leave the land in such a wrecked condition that much labour has to be spent afterwards to get the land fit to cultivate, whereas with hand work you can generally fill in as you go and be ready for cultivation immediately.

These are the kinds of reclamation that I think are within the economic possibilities at the present time—smaller drainage problems, the fringe of the moorland, the rough spaces that occur on every farm, and the areas occupied by hedges and shaws. The big State schemes are out of the question so long as the relative values of labour and land remain at their present level. But I want to plead for reclamation of the smaller kind and also for the recognition of the chemical factors that result in our comparatively barren land. I should say even 50 per cent. of English cultivated land is yielding only three-quarters of what it might yield if only it was limed or chalked. Much of this inferior land could be dealt with profitably and at once by recognizing the chemical fact that you cannot have fertile land unless it is limed; again that you cannot get crops upon the heavier land without phosphoric acid, and upon the lighter land without potash. Without trying to do anything very big or wholesale, it is this kind of reclamation that can be made to win for production in this country a great deal of land which at the present time is not doing its duty.

# POLITICAL ASPECTS OF AGRICULTURE

## *AN ADDRESS*

*Given at the Dinner of the Plough Club*
*(School of Rural Economy, University*
*of Oxford), November* 19, 1920

BY

LORD BLEDISLOE, K.B.E.

OXFORD
PRINTED AT THE UNIVERSITY PRESS
BY FREDERICK HALL, PRINTER TO THE UNIVERSITY

# POLITICAL ASPECTS OF AGRICULTURE

*An Address given at the Dinner of the Plough Club, School of Rural Economy, University of Oxford*

As an old Oxford man it has been my fond hope for at least thirty years that, under the shelter of this old University, which has been maintained mainly out of the revenues of agricultural estates, and which has reckoned among its sons more men of the landed class, and more distinguished statesmen than any other home of learning, it might be possible for future landowners, farmers and statesmen alike, to gain some direct knowledge of the science and practice of agriculture, and the realisation of its fundamental importance to the welfare of the kingdom. The existence and numerical strength of your Plough Club are the best evidence that that day has now come, and no one more fervently rejoices in the fact than I do.

Your President has asked me to address you this evening on the 'Political Aspects of Agriculture', and especially upon the Agriculture Bill now before Parliament. This is a subject which is less attractive to me than the economic aspects of agriculture, because I am bitterly conscious that (owing, perhaps, to the defective training of several generations of Oxford men) British agriculture has long been the shuttlecock of politicians, and to a large extent a mere pawn in the political game. For forty years 'the political aspect' of the industry may be described as one of apathy and neglect. It is true, however, that at long intervals, and under the pressure of necessity, some useful Acts of Parliament affecting the industry have been passed into law. Notable among these are the Diseases of Animals Acts, consequent upon the ravages of seriously contagious diseases which threatened the decimation of our livestock in the eighties and nineties of last century; and let me in passing say that as our farm animals, pre-eminent among those of the civilised world, have through the most depressed period of our agricultural history, been the sheet-anchor of British farming, any attempt to remove the embargo which has in the interests of health for many years been placed upon the importation 'on the hoof' of livestock from abroad, either for the alleged benefit of English graziers, or for diplomatic reasons, should be regarded with apprehension by all those who recognise the supreme importance of our animal husbandry. Amongst other agricultural measures which have been placed upon the Statute Book are the Fertilisers and Feeding Stuffs Acts, which have to some extent protected the purchasers of these raw materials of the agricultural industry against fraudulent adulteration, although in their administration the veto placed by the Ministry of Agriculture upon contemplated prosecutions by the County Councils has operated against their full utility. Small Holdings Acts have been passed enabling small areas of land to be secured by the County Councils, under statutory authority, for the land settlement of small cultivators, and several Agricultural Holdings Acts (culminating in that of 1908) have ensured for tenant farmers some measure of compensation for their unexhausted improvements, and of security of their tenure. Unfortunately in their administration such security has been enjoyed almostly equally by good and bad tenants alike, with a resulting depreciation in the once relatively high standard of British farming. More recently the Milk and Dairies Act, 1915, has been passed into law, although not yet brought into operation. It is now sought to amend it by a similar, but more drastic Bill, the intention of which is to secure a cleaner and more wholesome supply of milk by giving the Ministry of Health a power of far-reaching control, through the medium of licences and departmental orders, over all 'dairymen' (including cowkeepers) and dairies throughout the country. My only fear in connection with such legislation is that too much interference with the dairy industry, at a time when it is seriously unsettled, may tend, by drying up the milk supply, to reduce, rather than improve, the standard of the national health. A sufficiency of milk is more important than its entire freedom either from dirt or from bacteria.

Speaking generally, as long as cheap food was obtainable from overseas, agriculture was not the serious concern of any political party or any Government. Then came the War, and with it the realisation that with such a factor as hostile submarine attack, the transmarine carriage to our shores of four-fifths of our breadstuffs and 40 per cent. of our meat supplies was an element of grave risk to the safety, and indeed to the existence, of the nation. The result of the alarm thereby engendered was the passing of the Corn Production Act, 1917, with its guaranteed minimum prices, its control of cultivation, and its establishment of a statutory minimum wage for agricultural workers.

The Agriculture Bill, which is intended to have more permanent operation, amends both the Corn Production Act, 1917, and the Agricultural Holdings Act, 1908. Its main purpose is to provide some permanent scheme for securing the maximum home production of breadstuffs. This object is sought to be achieved by three main agencies:

(1) By guaranteeing the corn-growing farmer against serious financial loss.

(2) By enforcing good husbandry, and even changes in the methods of husbandry, through the medium of the new County Agricultural Committees.

(3) By giving the tenant farmer greater security of tenure, so that he may employ with confidence his capital and energy in developing his holding to its utmost capacity.

As a condition of the above guarantee a minimum wage must be paid by the farmer to his employees at the rates fixed by the Agricultural Wages Board.

The guaranteed prices of wheat and oats will start from the 1919 datum level of 68*s*. per quarter (504 lb.) for wheat, and 46*s*. per quarter (336 lb.) for oats. They will vary each year as the costs of production in that year may vary with those of 1919. The great merit of the Bill, in my judgment, is that it bases these guaranteed prices for the first time upon the costs of production, including particularly that of labour.

Among other useful, but subsidiary, objects of the Bill are the protection of farm-workers against sudden or capricious eviction from 'tied' cottages on cessation of their employment and the provision of compensation to allotment holders in the event of their dispossession after short notice.

The Bill is having a troubled passage through Parliament and may conceivably be thrown out in the House of Lords, with resulting embarrassment to the present Government. The two issues round which the battle over the Bill is being mainly fought are:

(1) The measure of control over the industry which the Government is justified in exercising.

(2) The basis of compensation for alleged loss to be paid to a tenant farmer in the event of his being disturbed in his holding by his landlord.

Upon both these questions, and especially upon the former, I find myself opposed to the Government, although prepared to support, perhaps rather reluctantly, the general purposes of the Bill. Having been myself a 'Controller' during the War period, I realise to the full the evils and the dangers of permanent Government control. Of all British industries agriculture seems to me to be least susceptible to Government interference. It depends so much upon conditions, like the weather, which are beyond human control, and upon other conditions, such as those of soil and local climate, which vary in different parts of the kingdom. It is one thing to control (and thereby level up) the standard of husbandry; it is quite another to control the method or system of farming. There is plenty of scope for improvement in the former, as for instance where arable fields are continuously full of couch or of charlock, and where successive white straw crops are being grown on the same land without adequate fertilisation, or where land is left fallow during the summer months without sufficient reason. But bad husbandry is not confined to arable crops, as is sometimes ignorantly supposed. Outside interference is just as necessary where for instance meadows, through neglect, are full of ox-eyed daisies, yellow rattle, quaker grass, sorrel or cowslips, or where milk is being continuously sold off pastures without manurial recompense. Such interference, you will probably agree, is in the interest of the individual as well as of the community, and if the landlord cannot or will not exercise control in such matters, the Government must. It is no exaggeration to say that if the standard of husbandry throughout England were raised to the level of the best in every neighbourhood, the aggregate present output of corn, potatoes, meat, and milk might easily be doubled. But the Government are asking for wider powers than this. They are seeking for the control not only of the standard, but also of the system of farming, and especially the power to compel the ploughing up of grass land. It is probable that the reservation to the Government of a general power to enforce cultivation 'according to the rules of good husbandry' would ensure an increase of the arable area in most cases where it is really advisable, and where a net increase of food output would result. But to tell a farmer how he ought to farm, to convert for instance, by Government mandate, a dairy farm into a corn farm would, in my opinion, be carrying Government control much too far. Nor would such interference necessarily result in any continuing increment in the yield of human food. This has been the experience over large areas in the west of England and Wales where 'permanent' grass has been put under wheat during the War, but where soil and climate are less suitable for its production than in the eastern counties. Although good corn crops may be raised temporarily by feeding them on the accumulated fertility of turned-up pasture, it is at least open to doubt whether such land will yield *continuously* more human food, and at a fair profit to its producer, by its conversion to arable than it did formerly under grass, assuming that the grass was fairly treated. It is noteworthy in this connection that ten counties out of a total of eighty-six in Great Britain grew more than half of its wheat output under normal conditions before the War. This suggests the conclusion that a larger aggregate output of human food might be obtained by intensification of effort in the more suitable localities than in a sporadic effort extended to less favourable areas throughout the country. It seems difficult at least to justify the production in a good season of from two and a half to three quarters of wheat to the acre on land better suited to other crops, and to expect the British taxpayer to maintain the process by a Government subsidy. Moreover, if the Government can dictate the system of husbandry there is a serious risk that political considerations will in the future operate in favour of methods which would employ the most labour, although possiblyat an uneconomic price. It is doubtful whether it is wise in a country with such an uncertain climate as ours to stake so much in times of emergency upon wheat, to the possible exclusion of such products as pigs and potatoes, which have the merit of rapid reproduction, of yielding a large quantity of food of high calorie value, and (in the case of potatoes) of providing by no means a bad substitute in the matter of carbohydrates for the so-called 'staff of life'.

The other critical issue in connection with the Agriculture Bill is the amount and basis of compensation to be paid to a farm tenant to whom his landlord gives notice to quit for reasons quite consistent with good husbandry, as, for instance, to constitute small holdings, to make a public recreation ground, or to enable the owner or his son to earn his livelihood by farming the land himself. No compensation is at present payable to an annual tenant to whom notice to quit has been given, except where the disturbance is unreasonable, and in that event it is limited to an amount which represents the loss incurred in consequence of the removal of his livestock and household goods. This amount of compensation is by the present Bill allowed even in the case of 'non-capricious' disturbance, and to it is added the equivalent amount of one year's gross rent of the holding. There is no doubt that under the existing law a dispossessed tenant is often insufficiently recompensed for his loss on quitting, but it is probable that under the above provision the compensation may in some cases be excessive and create hardship. It might be deemed fairer to both parties, as it would certainly be more logical, to award to the tenant compensation for the loss which he has actually suffered.* This, however, would involve the arbitrator in some difficulty as to whether he should include losses in respect of some other business carried on concurrently with the farm, but wholly distinct from it—e.g. a public-house, or a retail dairy business, and also whether it should include 'goodwill', e.g. as representing a commercial advantage resulting from connection with, and knowledge of, a particular local market. One year's gross rent as a basis of compensation cannot be logically or judicially defended. It is estimated by actuaries as roughly the equivalent of an average of seven per cent. of the capital value of the holding. It represents in fact considerably more than one year's income from the holding, as the landlord has to pay in respect of it land tax and tithe, as well as the ordinary outgoings of maintenance, repairs, insurance, and management, not to mention Income Tax, and perhaps Supertax. The attempt to provide in this way for a farmer's greater security of tenure may in fact render his tenure less secure by the temptation afforded to the landlord either to sell the farm outright, or to farm it himself.

The Agriculture Bill is at best a troublesome necessity in order to reduce the risks of national starvation in times of emergency, and at worst it is a downward step in the direction of State Socialism, and the destruction of individual enterprise. If the Oxford Plough Club had but existed a generation ago, when I was myself an undergraduate, there would be no need now of an Agriculture Bill, and the War, which was largely provoked by England's risk of starvation, might never have occurred. During the last thirty years, and indeed for long before, the majority of our statesmen have been Oxford men, brought up in an academic atmosphere in which agriculture as an educational subject would have been regarded as vulgarly bucolic, in which the importance of agriculture as the very foundation of the nation's welfare received scant consideration, and where a prospective landowner was trained for almost every occupation except that which his own domestic environment would naturally suggest, and in the pursuit of which he could best have achieved his own prosperity, and the truest welfare of the nation. Landowning is a serious, complicated, and very responsible business. No one who is not trained for its duties should, in the national interest, be permitted to enjoy its privileges, or such status as it may be deemed to afford. Lucky is the man who can partake of the training and opportunities which Oxford now provides. Never did England need to a greater extent leadership in the countryside than she does to-day. She wants 'white men', live men, men of courage, and above all men of knowledge, to point the way. She needs a 'Turnip Townshend' or a 'Coke of Norfolk' in every county in the kingdom, but he must possess too some of the qualifications of a Liebig or a Lawes if he is going fully to justify his leadership. Technical knowledge will alone enable him nowadays fully to appreciate the difficulties which the countryman has to face. He must recognise especially the necessity for the 'regional' development of agriculture: i.e. for finding the systems of husbandry, and the varieties of crops and of animals best suited to his own locality. He must, moreover, realise that agriculture runs normally on a very narrow margin of profit, so that the best possible equipment (mental, moral, and material) is essential if the countryman is to make his position stable. He would also do well to bear in mind that while science can do much, the operations of the agriculturist are always dominated by greater forces than our own, so that when all is done the farmers' risks are greater than those of the average manufacturer, and therefore some equalising insurance or guarantee methods may be necessary.

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* An amendment to this effect (but excluding concurrent businesses) was carried on the motion of Lord Bledisloe on the Committee stage of the Bill in the House of Lords without a division, but was excised on the Report stage in favour of the basis of compensation specified in the note on page 13.

Surely Swift was right when he said "Whoever could make two ears of corn or two blades of grass to grow upon a spot of ground where only one grew before, would deserve better of mankind, and do more essential service to his country than the whole race of politicians put together." It should be noted that, unlike some modern politicians, Swift did not forget the 'two blades of grass'. Knowledge coupled with self-reliance (and the one breeds the other) has been the secret of the success of all our great agriculturists. The worst features of Government control—particularly of control of prices—are that it removes the incentive to personal effort and industry, and involves dangerous uniformity of treatment. A reasonable price for the product of a small business is much too high for that of a large one with lower standing charges to meet, and greater facilities for economic administration. Moreover (and this applies especially to agriculture), a reasonable price in one part of England may be unreasonable in another, especially if the cost of the labour employed is roughly identical. Thus wheat can be raised in the sunny and comparatively rainless climate of East Anglia at less cost and in greater bulk to the acre than in Wales, the west of Scotland, or even upon the Cotswold Hills, where the rainfall is heavier, and on the whole the soil less tractable. So also milk can be more economically produced in the south-west of England than (for instance) in the Weald of Sussex. If a particular type of farming cannot, even with good husbandry, be made a source of commercial profit, it is useless to try to enforce it by Act of Parliament. The only result will be that the land will become derelict.

Economy is nowhere more necessary than it is in agriculture. Under normal conditions it makes all the difference between substantial profits and serious losses. Waste is generally due to ignorance. This is particularly noticeable as regards the use of artificial fertilisers. Thus we sometimes see nitrogenous manures applied to meadows or pastures where they may only operate to coarsen the herbage, or prevent the growth of the more valuable leguminous plants. Similarly we may find highly soluble chemical fertilisers being applied at times when plants cannot avail themselves of them, with the result that their value passes out into the drains. So too we find potassic salts being sometimes wastefully applied to clay soils, which already possess a sufficiency of this manurial ingredient, and only require lime to render it available. Similarly basic slag is often applied to sandy soils, and superphosphate of lime to clay soils, when the converse would produce better results. Ignorant waste is hardly less observable in the use of feeding stuffs. Thus maize is often fed to fowls as their sole diet, or in excessive quantities, simply because it is cheap, with the result that egg-laying may be suspended by over-heating, and the white flesh of the table-bird be spoilt by ugly wallops of yellow fat. Cheapness too often dictates the feeding to farm animals (without regard to a balanced ration) of undecorticated cakes and meals with too large a proportion of indigestible fibre, which produce a return of meat or milk hardly commensurate with the outlay. Nor indeed is waste confined to the process of production; it often occurs, and is still more to be condemned, after production has taken place. Thus it is estimated that in London alone during a single year over £2,000,000 worth of milk is wasted through souring in the absence of proper precautions for cooling it prior to its transit from the farm to the metropolis. Several million pounds' worth of corn in stack are lost every year from the ravages of rats, through lack of staddles, or the want of a good cat or dog. So too potatoes to an incalculable extent are every year lost in clamps or in sheds through want of suitable and proper protection against frost and disease. Probably the greatest loss of all is that of the manurial constituents of farmyard manure in the absence of its protection against the weather, or of liquid manure through want of collecting tanks.

In conclusion allow me to say that as Chairman of the Managing Committee of the Lawes Agricultural Trust I am profoundly anxious that there should be a more intimate relationship between Rothamsted and our Universities, so that the invaluable and interesting results of the research work, both on soil problems and on plant pathology, which is continuously being conducted there by some of the ablest young scientists of the Empire, may be rendered available in intelligible form for agricultural students, as well as for County Agricultural Directors, throughout the kingdom.

# NOTE

At the time of the delivery of the above address the Agriculture Bill was passing through its final stages in the House of Commons, and had not been considered by the House of Lords. It underwent substantial alteration in the Second Chamber, and eventually received the Royal Assent shortly before Christmas. The chief alterations effected by amendment in the Upper House were:

1. The elimination of the power to compel the sowing of wheat or any other crop or even the conversion of grass land into arable, Government control being confined, in effect, to

(*a*) The cultivation of all agricultural land (whether arable or grass) according to the rules of good husbandry.

(*b*) The maintenance or increase of food production by the occupier of agricultural land 'without altering the general character of the holding'.

2. The omission of special compensation for so-called 'capricious' disturbance, and the assessment of compensation for 'non-capricious' disturbance at one year's gross rent, unless the tenant can prove that he has suffered loss of greater amount, with a maximum in any event of two years' gross rent.

3. The grading up of the general standard of farming in the national interest by defining the 'rules of good husbandry'. (These have been interpreted in the past by the vague common law, or by the custom of the country.)

4. The exclusion of park, garden, or any other 'amenity' land adjoining a mansion house from the expression 'holding' for the purposes of compensation for disturbance.

BLEDISLOE.

Lydney Park,
*January* 1921.

# HEREDITY AND BREEDING

BY

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*A Paper prepared for the*
*Excursion by the School of Rural Economy*
*Oxford University, to his Farm on*
*February* 2, 1922

OXFORD
PRINTED AT THE UNIVERSITY PRESS
BY FREDERICK HALL, PRINTER TO THE UNIVERSITY

# HEREDITY AND BREEDING

THE breeder of live-stock has to deal with two factors, both of which influence heredity, (1) the Mendelian character, and (2) the effects of environment. Most scientists have unfortunately confined their attention to the former, and have denied that the effects of environment are inherited. The breeder, on the other hand, has always gone on the assumption that they are. Very little progress, if any, was made in the improvement of our breeds of live-stock until the introduction of the turnip provided adequate supplies of winter food, and put an end to the annual period of starvation, which Mr. Prothero (now Lord Ernle) describes in his book on British Agriculture; and immediately not only the Shorthorn, but every breed of cattle and sheep made a simultaneous and rapid advance. The breeder has always insisted on the generous feeding of his stock, which was against the interest of his pocket. He made use of prepotency as one of his chief instruments to effect his purpose, and he regards a robust and vigorous masculine appearance as the principal indication of a prepotent sire. Prepotency is the power possessed by an individual to impress his own characteristics on his offspring to the exclusion of those borne by the one he is mated with. All of these facts are not only contrary to Mendel's teaching, but scientists have been at a loss to explain them.

Scientists have always confined their breeding experiments to the vegetable kingdom or to small animals kept in cages, and neither prepotency nor variation due to the environment have been active factors to be reckoned with. Within the last few years Mr. J. L. Bonhote studied heredity amongst birds and animals in the wild state in various parts of the world, where the conditions approximate more closely to those prevailing on the farm, and from his observations he was able to enunciate general principles which govern the influence of environment upon heredity.

The results of his investigations (*Vigour and Heredity*, 1916, West, Newman & Co.) elucidate the problems of stock breeding, and justify the methods which the breeder has adopted for the last couple of hundred years. Scattered through scientific writings we often find vague and scanty references to vigour as a factor, if not actually influencing heredity, at least with some bearing on the characteristics of the individual. Mr. Bonhote defines vigour as activity of nutrition and function, or as the rate of metabolism, which varies as between one individual and another, and is increased by a favourable and decreased by an unfavourable environment. Every individual inherits at the time of conception a measure of initial vigour which is approximately equal to the mean of the vigours of the parents at the time of service. If after the birth of the first offspring the vigour of the parents is increased by a more favourable environment, the initial vigour of their second offspring will be greater than the initial vigour of the first. This initial vigour may be increased or decreased within limits by the environment, and the increase or decrease may be handed on to the second generation, and thus if the environment continues to be increasingly favourable, the increase will be handed on in the cumulative principle to succeeding generations.

The coloration of birds and animals is due to pigment, which is chiefly fatty substances, waste products of the metabolism. Therefore the amount or density of colour is a rough index of the rate of the metabolism or the vigour of the individual. In the polar regions, where the conditions are unfavourable, the colours of the species are generally white or dull coloured. The few high-coloured species such as the Raven and the Leming are distinguished by specially high vigour, which is demonstrated by breeding exceptionally early in the year, by their exceptional fertility or great pugnacity. The migratory birds moult in the warmer climates, when they assume bright colours, and they moult again in the cold regions, when they assume a dull dress approximating to the local species. In warm climates, where the conditions are favourable to high vigour, colours are generally bright. The few white species that do exist are unable to live outside the most favourable regions, whilst their more highly coloured relations are found over a wider area.

These observations, of which I have only given a very skimpy summary, do show that vigour depends on the environment, of which the chief factors are temperature, humidity, and food supply. Mr. Bonhote then closely inbred a small Egyptian animal known as a Merione, during several generations, and he obtained an increasing loss of colour and decrease in size each generation; and by outcrossing he restored the colour and the size. When Mr. Bonhote left Egypt he caught some wild rats in the Zoological Gardens in Cairo and brought them to London, where some of them bred soon after arrival. Amongst the offspring were some fawn ones, and also others that exhibited the same waltzing movement as the mice Mr. Darbyshire describes in his book on Mendelism. Mated with normal-coloured rats, the fawn colour proved to be a recessive character, like the waltzing character of Darbyshire's mice. Fawn rats that were brother and sister were then mated together, and in the second generation some of the offspring were blind owing to the absence of the optic nerve, and others were so weak that they died soon after birth. It was not possible to breed from the second generation, but by analogy the character for blindness should be recessive. The lesson to be learnt from these experiments is that a reduction in vigour in the first generation is handed down on the cumulative principle to the second. In the first the loss of vigour, in the case of the parents due to confinement and change of climate, was sufficient to cause slight degeneration, which showed itself in loss of pigment; but close inbreeding of the already degenerate parents lowered the vigour still further, and produced blindness and the inability to live in the second. We also notice that by reducing the vigour new characters made their appearance, which proved themselves to be Mendelian recessives. Professor W. E. Castle of Harvard (*Genetics and Eugenics*) states that inbreeding favours the production of Mendelian recessives, whilst outcrossing favours the appearance of dominants, which, since inbreeding reduces vigour and outcrossing increases it, is tantamount to saying that variations in vigour may have the effect of modifying the operation of Mendel's Law.

It is not often that scientific methods of investigation are applied to elucidate an agricultural problem, but in 1908 what is known as the Arkansas Cow Experiment was carried out by the Iowa State College of Agriculture to determine the effects of breed and feed on stock. The college got together a lot of typical scrub dairy cattle, including seven cows, four heifers, and a bull. On their arrival at the college they received the best food and attention, and milk yield was used as an index as to what extent they profited. A summary of the results is as follows. The old cows did not increase in production after the first year, but it cannot be said that they did not give rather more than they did under their old conditions. The cows that were four years old on arrival increased in production rapidly and steadily up to the fourth lactation period, when they produced 59 per cent. more milk and 54 per cent. more fat than they did during the first period. The four heifers when they came into milk gave 13 per cent. more milk and 12 per cent. more fat than did the cows that were four years old on arrival. The cows were then mated with pedigree dairy bulls. The average of the records made by the first generation heifers was 71 per cent. more milk and 42 per cent. more fat at an average age of 3½ years than their scrub dams at six years old.

The chief point about this experiment is that it was not just a case of putting food in at one end of the cow and drawing off the milk at the other. The cows had to be generously fed and cared for for three years before they gave the maximum quantity of milk. In other words, it was necessary to build up the cows and increase their vigour before they would give the best results. The old cows, it is important to notice, were too far gone to respond to treatment, whilst the heifers which were caught at an earlier age were rather more responsive than the four-year-old cows. There was, however, a definite limit to the increase in vigour resulting from an improvement in feeding. Roughly the yield of the original stock was increased by 40 per cent., but their daughters gave on an average 110 per cent. more than their dams gave on their arrival at the college. Part of this increase was due to an improved environment during the two generations, and also to increased vigour derived from the pedigree sire. Mr. Bonhote states in general terms that the offspring inherits an initial vigour corresponding to the mean vigour of the parents, and that this mean vigour may be increased to a limited extent by an improved environment, when the increase will be handed on to the next generation. The Arkansas Cow Experiment is a quantitative statement of the same phenomenon. Besides the experiment with the milking cows, the college experimented in the feeding of four scrub calves compared with the feeding of four ordinary commercial calves. Both lots of calves had the same amount of food, and their daily gains in weight were recorded. The average daily gain of the scrub calves was 1·12 lb., whilst the average daily gain of the commercial calves was 1·61 lb. We defined vigour as activity of nutrition and function. If its vigour is low the animal cannot make the best use of the food when it does get it. We see the same thing on the farm. Take two bunches of bullocks in the autumn, keep one in a yard all the winter and feed them well, and leave the others out in a bare pasture without any other food. When the grass comes in May the lot that have been fed during the winter will go away at once and thrive; those that have been starved all the winter will not make any progress for some weeks, and will be on our hands for some time after the others have gone to the butcher.

High-vigoured stock will grow well and thrive, and will produce large quantities of milk, beef, or wool, as the case may be. Low-vigoured animals will be scrubs—small, undersized, and stunted, bad doers that will not make the best use of the food we do give them, and in fact will not pay for their board and lodging. The chief object in using a pedigree sire on commercial stock is to increase the vigour of the offspring. Pedigree animals should be higher vigoured than commercial stock, but this is by no means the case. It is a waste of money to pay a good price for a pedigree sire and to underfeed him as soon as you get him home. You are throwing away the vigour you paid for. We often hear a good deal of criticism of the way in which pedigree bulls are reared—pampered it is called. I am firmly of opinion that the so-called pampering of bulls, feeding them till they reach the highest possible pitch of vigour, is the main factor which contributes to success in stock rearing. My experience is that the first calf of a heifer is nearly always a failure. It never grows as it should, and is generally deficient in size, type, and milk yield. A heifer's first calf is conceived when the dam has not reached maturity, so that her vigour has not reached its highest level. The calf therefore inherits the dam's low vigour and starts off in life with low initial vigour. The offspring of an immature bull will be equally bad. We often find that an immature red Shorthorn bull gets calves with a good deal of white about them, whereas his later calves will not have any white. The white markings are an indication of low vigour which the calf has inherited from the low-vigoured immature bull. I believe it to be the case that all great dairy sires have been born when their dams have been at their maximum vigour—five to six years old.

There are several breeds of pony, New Forest, Dartmoor, Welsh, Shetland, &c. They all possess a well-defined pony type which is distinct from the type of the horse. They all lead a rough life on waste land, where the conditions result in low vigour. If a horse stallion is turned out in the New Forest his influence is visible for a couple of generations, and is then lost. That is to say, he increases the vigour of his offspring, but in a couple of generations the environment will reduce the vigour till they reach the level of vigour with which the pony type is associated. In his book on the breeding of race-horses Mr. Bruce Lowe says that however good a horse may be as a performer on the turf he is never bred from if he has a 'pony head'. An animal that attracted a great deal of attention at the Manchester Royal in 1916 was an ostensible Shetland pony that was led round collecting subscriptions for some charity. It was stated that the pony was the offspring of two normal shire parents. A breeder of horses wrote to the papers and said he could understand the diminutive size, but where did the pony get the correct pony type? What happened was that something went wrong with the works, and the pony inherited from its big parents only sufficient vigour for the frame of a Shetland pony, and the pony assumed the type associated with that small measure of vigour, just as Bonhote's low-vigoured rats assumed a fawn colour. At the other end of the scale we have the type which should be associated with good breeding, in other words high vigour. There is an old saying that it takes three generations to make a gentleman, that is for the family to reach the level of vigour associated with the characteristics of a gentleman.

Professor Marshall, Professor of Animal Husbandry, Ohio University, says: 'Prepotency in untested breeders is evidenced by that combination of physical attributes that gives to an animal a pronounced individualism, or, as breeders term it, character. Character is contributed to by three things, style, high development of the appearance associated with sex, and that robustness and vigour of expression that can only be present where perfect health and spirits are coexistent. . . . The robustness and vigour of expression read in the countenance and mainly in the eyes, and also reflected in boldness of movement, are probably the most directly associated with prepotency of all the things that may be regarded as contributory to character. The appearance and manifestation of maximum vigour and vitality can only be present where all the organs of the body perform their full work. The presence of this condition insures the highest vigour, vitality, and activity of the germ cells. It cannot change the make up of the germ plasm, but it may control its strength and power, and thus give it a much higher degree of prepotency than would be possible if the animal had been in low physical vigour.'

What Professor Marshall says is that character or the indication of a prepotent sire is the result of high vigour. We saw in Mr. Bonhote's rat experiment that the normal coloured rat was a Mendelian dominant over the fawns and waltzing rats that were produced by reducing the vigour, and by analogy a high-vigoured prepotent sire is dominant over a low-vigoured or lower vigoured female, and transmits his characters to the offspring to the exclusion of the characters borne by the female. But a sire will not be what we understand by prepotent unless he has the power to stamp all his offspring with the same characteristics, and he cannot do that unless his ancestry is homogeneous or practically so. Therefore in practice we find that prepotent sires are nearly always more or less closely inbred. On the other hand, it is not by any means the case that every inbred animal is highly prepotent. You must have the two factors, high vigour to secure a dominance over the individual he or she is mated with, and a homogeneous ancestry so as to be able to transmit the same characteristics every time.

Before we deal with inbreeding we must turn to what I have called the Distribution of vigour. Growth, size, the production of milk, flesh, and wool all depend on vigour, or the action of metabolism. If we were to tell a physiologist that we divert vigour into the milk-producing organs he would say we were talking nonsense. I quite agree, but when we are discussing heredity it is a convenient way of expressing the physiological phenomenon we wish to describe. Mr. Bonhote was dealing with wild animals, rats, &c., in which, if we may say so, the vigour is equally distributed amongst the various functions. Now when we come to farm animals this is not the case, and what we may call the unequal distribution of vigour amongst the various functions has a marked effect on heredity.

By selective breeding we may increase the milk production of our dairy cattle, and it is well known that if we increase the milk beyond a certain point we shall lose the flesh, till in the case of the Jersey cow we get a big milk yield and a bag of bones. Now even if we dry the cow off it will be impossible to get any flesh on her. On the other hand, if we increase the flesh we shall lose all the milk, and the cow will be unable to suckle her calf. What has happened is that by increasing the milk yield we have deprived the beef-producing organs of the vigour necessary for them to function; and if we increase the beef beyond limits we deprive the milk-producing organs of their necessary vigour. A very important point is that we are unable to utilize the Jersey cow's milk-producing vigour to produce beef when she is dried off and the vigour is no longer required for milk production. I therefore regard each function as possessing a distinct supply of vigour, and that the vigour supplied to one organ will never be available for another. This I call the distribution of vigour. Subject to the usual variation always found in heredity, we find that the distribution of vigour in the parents is passed on to the offspring. Bag-of bones dairy parents will have bag-of-bones daughters that will be big milkers. Beef parents will have beef offspring.

If we regard the reproductive function as being a separate and distinct function with its own distinct supply of vigour, like the milk and flesh-producing functions, we shall be able to explain several problems of heredity. When a white guinea-pig is mated with a black the offspring are always black; black in this case being dominant over white. Professor Castle removed the ovaries from a white female, and substituted those from a black one. About a year later he mated this female with a white male, and still her offspring in several litters were black, showing that the offspring were produced from the germ cells alone, and that the germ cells had not been influenced by contact with the body of the white female. There is therefore good ground for asserting that the reproductive function is independent of the other functions of the body, and we can I think say that the initial vigour that the offspring inherits is the vigour which is present in the germ cells only, and not the vigour which is ear-marked for the other functions. We can also assume that the vigour available for the milk-producing or other function may be greater than the vigour available for the germ cells. In other words, that the unequal distribution of vigour between the flesh and milk in the Jersey may also apply to the germ cells.

Most breeders prefer animals of moderate size to breed from. If they are too big too much of the vigour is utilized by the frame at the expense of the vigour in the germ cells, which I call genetic vigour. Hence the initial vigour of the offspring will be low. Excessive milk production reduces the genetic vigour, and hence the offspring are low-vigoured and are only moderate milkers. I had one cow that gave 1,300 gallons and another 1,200, and none of their daughters are big milkers. American breeders say that the offspring of record milkers are nearly always failures. An animal may be so well developed physically (and prizes go to the best physically developed animals) that too much vigour has been absorbed by the frame, consequently his genetic vigour is low, and his offspring are low-vigoured, and although a great prize-winner, he is a failure as a breeder. On the other hand, a great breeder is often a moderate individual. One can go further. We often find that the ancestors of an exceptional family line have been small undersized individuals themselves. Lincolnshire Lad 2nd was a very plain common-looking horse, with his middle under-developed, yet his descendants have been prolific as prize-winners and also as great breeders. In Clydesdales, of two own brothers, Macgregor and Flashwood, Flashwood was much the better individual of the two, but was a failure as a breeder. Macgregor was plain, but a great sire. Lily Agnes was such a weed that Sir Tatton Sykes wanted to clear her out, but she produced four daughters who were very great mares, and one of them was dam of Ormonde. In Shorthorns Hubback's dam was a small cow, but Bates considered Hubback to be the best bull that ever lived. In these cases genetic vigour is increased at the expense of the vigour of the other functions, hence the offspring are exceptionally high-vigoured, and will therefore be celebrated individuals, or great breeders, or both. Suppose a calf is born with a 600-gallon ancestry, and suppose the calf's vigour is increased by good feeding so that it is higher vigoured than the parents. If the whole of the increase is diverted into the milk-producing organs, it may give 800 gallons, yet its genetic vigour will only remain at the 600-gallon level, and its daughter will only give this quantity. We often find sports as regards milk production, and this I think is the explanation.

Scientists tell us that if an individual deviates widely from the mean height of the ancestry, the offspring will tend to regress towards the mean. This is called the Law of Filial Regression. Scientists put it forward but do not explain it.

If a variation in vigour affects the development of one particular function only, and does not result in a corresponding variation in the genetic vigour, the abnormal development of the function will not be transmitted to the offspring. In exceptional cases an abnormal development of one function will encroach upon the supplies of vigour to the germ cells, consequently the vigour of the offspring will be lower than the vigour of the grandparents, and the development of the function will be subnormal. The action of this machinery therefore militates against the inheritance of any sudden development, but it is not inimical to gradual evolution. In order that the development of any particular function may be inherited it must be accompanied by a corresponding increase in genetic vigour. As we have seen the increase in vigour due to environment in any one generation is limited. If this limited increase be evenly distributed amongst the whole of the functions including the germ cells, it follows that the increase available for any particular function will be small. In other words, the individual will not deviate widely from the mean of his ancestry in any particular, which is the Law of Filial Regression.

Judging from the inheritance of mild yield and the inheritance of broken colours, what I call the distribution of vigour is Mendelian. It is also evident that the pure beef Shorthorn produces a minimum quantity of milk, and the Jersey produces a minimum quantity of flesh. Therefore the difference between the minimum function and the full function is a question of degree. In the *Journal of the Ministry of Agriculture*, April–July, Mr. Punnett deals with the factorial theory. The idea is that if one factor is present a function will be developed so much; if two are present the function will be increased; still more if three factors are present, and so on; and that these factors are inherited according to Mendel's Law. I think the factorial theory and the distribution of vigour means the same thing except that the distribution goes further and shows that the development of a function may affect the genetic vigour and so influence heredity.

Inbreeding was first practised by Bakewell. The results he got were smaller bone and smaller offal. Probably these are Mendelian recessive characters. Charles Colling learnt the practice from Bakewell and practised it on Shorthorns. His results were certainly successful, and he produced the bull Favorite 252, which was a great advance on anything seen before. All the early Shorthorn breeders founded their herds by concentrating the blood of this bull.

The practice of inbreeding is nearly universal amongst breeders of live-stock. It produces uniformity and reduces the lottery of breeding. It ensures a certain degree of prepotency, and it secures the continuance of desirable recessive character, such as an inherited tendency to milk. Professor James Wilson (*Principles of Stockbreeding*) says: 'Indeed there is scarcely a British breed of live-stock but was established by inbreeding and has been maintained in some degree on the same theory down to the present time.' He then goes on to say that whereas all the best breeders have been in favour of it, the rank and file have always been against it. Let us examine this problem in the light of the vigour theory. The best breeders have always done their stock well and the others have not. Those that did them well were able to counteract the loss of vigour due to inbreeding, and so get the benefits without the drawbacks. The others lost vigour and so only encountered the ill effects without the good ones. Each class then speak as they find.

Inbreeding is strictly the mating together of two closely related individuals. There is also a modified form of inbreeding known as Line Breeding. This consists of mating two individuals, not close blood relations, but belonging to the same strain or blood. These will bear the same characters without being of close consanguinity. Inbreeding has the effect of producing uniformity. If an animal is mated with another bearing the same characters as itself it is evident that the offspring can only inherit those characters and no others. That is to say, the offspring will resemble the parents. Inbreeding fixes the character, and the longer inbreeding has been carried on the more stable will the character become. Why inbreeding should render a character prepotent is a big and possibly open question. However closely we inbreed we must introduce a certain amount of alien blood. If we examine Bates's pedigrees we shall find as much as 75 per cent. of the blood of Favorite. Booth seems to have been content with 50 per cent., and Cruickshank's pedigrees only seem to show about 25 per cent. of the blood of Champion of England. We must remember we do not breed for the sake of inbreeding, we just want to inbreed sufficiently to preserve the type and to fulfil our requirements. However carefully we inbreed there comes a time when we must use an outcross to restore the vigour, and then comes the difficulty. As long as we introduce fresh blood in a diluted form we shall not do any harm to our type, but if we introduce it in a raw state, and this will be absolutely essential at times, we are apt to lose the points we have been trying to secure. William Carr in his History of the Killerby, Studley, and Warlaby Shorthorns deals at length with this point. He shows that however good the blood that Booth introduced, the immediate offspring were more or less a failure, but that when he bred back with his own blood he restored the type he had temporarily lost, and the second generation greatly benefited from increased vigour. We often find a family will become famous all at once, produce a brilliant constellation of winners, and then fizzle out like a damp squib. On the other hand, we have cattle like the Booth herds that were practically invincible in the show yard for half a century. Can we account for this? In the distribution theory I assume that a high supply of genetic vigour is essential to produce good offspring. If we wish to continue to breed good animals we must fix the supply of genetic vigour just as we fix milk production. Inbreeding fixes the one and it will also fix the other. I think the fact that the Booth cattle were inbred had a great deal to do with their long-continued success.

If you want to found a herd study pedigrees and the history of the breed before you begin, and save yourself from a false start. An American writer said the other day that on the average a new breeder starts three herds before he gets on the right lines. Get the herd books and work out the full pedigrees of animals bred by famous breeders like Bates, Booth, and Cruickshank, and study their methods. My own methods are simple. I want a fair individual. Otherwise I go for blood and trust to luck. I find it pays best.

British Association for the Advancement of Science.

SECTION M: BOURNEMOUTH, 1919.

# ADDRESS

TO THE

# AGRICULTURAL SECTION

BY

PROFESSOR W. SOMERVILLE, D.Sc.

PRESIDENT OF THE SECTION.

## *Grass.*

During the past four years—or since the ploughing programme began to take shape—grass land has been officially cold-shouldered in no small degree. The cause was obvious and the reasons were good. The result of compulsory and voluntary ploughing has been that whereas in 1914 the total area in Great Britain under temporary and permanent grass (hay and pasture) was practically 21½ million acres, it was barely 19½ million acres in 1918, a reduction, namely, of about 2 million acres. During the same period the arable area, other than temporary grass, increased from about 10½ million acres to 12½ million acres. In Ireland, during these years, the area under grass (permanent and temporary) fell from about 12½ million acres to less than 11¼ million acres. The United Kingdom at the present time comprises about 30½ million acres of permanent and temporary grass and 15½ million acres of land under crops other than grass and clover. This is over and above some 16 million acres of mountain land used for grazing.

It is far from my intention to attempt to maintain that grass land is, as compared with tillage, defensible from the point of view of national economy. It has been proved conclusively by various writers, and by none more convincingly than by Sir Thomas Middleton, that in respect of nutritive output, and the utilisation of labour, and in its bearings on foreign exchange, arable cultivation is much more attractive than pastoral farming. It is my sincere hope that the Royal Commission now sitting will be able to formulate a policy, acceptable to the Government, which will result in the retention for tillage of at least all that the plough has gained during the war, and, in my view, it would be well for the country if a much larger area even than that could be wrested from the grazier. But for the moment the tendency is in the other direction, and under the stimulus of high wages and increased costs generally, a certain amount of land has already been resown to grass, and preparations are being made for similarly dealing with an increased area next spring. It would, therefore, appear that under any circumstances that can be conceived the area of land under grass is likely to remain at a very high figure, and to be well worth the consideration of this Section of the British Association.

A considerable proportion of the grass land of this country is of so high a quality that any improvement, and certainly any economic improvement, is hard of accomplishment. Satisfactory as are the high-class pastures of this country, it by no means follows that there is nothing more to learn about them. Grazing practice is in general agreement that the productive capacity of these pastures is maintained by judicious stocking during the growing season, by the regular mowing of thistles and other coarse weeds, by the maintenance of the drains (if such exist), by the spreading of the droppings of cattle, by the avoidance of winter grazing (at least in the case of land liable to 'poach'), and, in many cases, by the consumption of a certain amount of cake, at least during the

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latter part of the season. On many of the high-class pastures no cake is used, so that the annual drain of nitrogen and minerals in the form of animal disease must be balanced—if fertility is maintained unimpaired—by the nitrogen gained in various ways from the air, and by the weathering of inert mineral matter in the soil. As, however, 300 lb. of live weight 'fattening' increase per acre per annum—which may be assumed to be about the maximum production of high-class pasture—will contain only about 3 lb. of nitrogen and a similar amount of mineral matter, the natural agents will have no difficulty in replacing this loss. It would appear in fact that, but for the loss of plant food by drainage and denitrification, even a fattening pasture should go on improving, and this is the case so far as accumulated fertility is concerned, though not in respect of current or immediate animal production. On a pasture of naturally low quality, where leguminous herbage stimulated by phosphatic manuring is the main factor of value, it has been proved at Cockle Park that the addition of nitrogen either as artificial manure or in the form of cake residues has been positively injurious or has produced a result disappointingly small, and one would like to see this subject followed up experimentally in the case of naturally rich pastures where cake is freely used. One would like to study in detail the effects of phosphate and potash on such land, although where production is naturally so high it is unlikely that it can be materially and economically increased.

It is often very difficult to determine the factor or factors that go to the making of high-class pastures. Such pastures are to be found on most of the geological formations of this country; they are met with north, south, east, and west; and even altitude, within the limit of at least seven hundred feet, seems to have little effect. An immense amount of attention has been given to the botanical composition of the herbage of the more famous of the pastures of Britain. Notable in this connection is the work of Fream,[1] Carruthers,[2] Hall and Russell,[3] and Armstrong.[4] The methods employed varied to some extent with the investigator. Fream had turfs dug up and transferred to Downton, where they were planted in the garden, the herbage being subsequently clipped over and separated; Carruthers, Hall and Russell relied partly on enclosing representative areas and sampling the herbage when well grown, and partly on occular estimation; while Armstrong used a frame a foot square divided by transverse strings into 144 square inches. This was placed on the sward *in situ* and a note made of the percentage occurrence of the different species of plant. The result that emerges most conspicuously from these researches is that one may have a dozen pastures, which are about equal in feeding value, and yet which may vary widely in respect of botanical composition. Thus Fream found that in the case of forty-eight English and eight Irish pastures, each of which was the 'best' in the district selected, the Gramineæ might be as low as 11 per cent. and as high as 100 per cent.; Leguminosæ might be entirely absent or as high as 38 per cent.; while of miscellaneous herbage, most of which would be designated as 'weeds,' there might be none or up to 89 per cent. As regards individual genera and species, Fream found, for instance, that Agrostis was almost always present and on five occasions was the most abundant plant; while *Holcus lanatus* gave an almost identical result. By a different method Carruthers arrived at a very similar conclusion. The latter also found that *Hordeum pratense* was the most abundant species on what is perhaps the finest grazing in England, namely, Pawlett Hams, near the mouth of the Parret in Somerset. This investigator even found that on one of the 'Famous Ancient Pastures of England' the predominant grasses were Fiorin and Hassock, and in this connection makes the following remark, 'In this field the hassock-grass, which made up a large proportion of the pasture, was freely eaten, and the cattle were in good condition.'

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[1] W. Fream, 'The Herbage of Old Grass Lands,' *Jour. Roy. Agric. Soc. Engl.*, vol. xxiv., 2nd Series, p. 415; and 'The Herbage of Pastures,' *Jour. Roy. Agric. Soc. Engl.*, vol. i., 3rd Series, p. 359.

[2] W. Carruthers, 'The Composition of Some of the Famous Ancient Pastures of England,' *Jour. Roy. Agric. Soc. Engl.*, vol. i., 3rd Series, p. 751.

[3] A. D. Hall and E. J. Russell, 'On the Causes of the High Nutritive Value and Fertility of the Fatting Pastures of Romney Marsh and other Marshes in the S.E. of England,' *Jour. Agric. Science*, vol. iv., p. 339.

[4] S. F. Armstrong, 'The Botanical and Chemical Composition of the Herbage of Pastures and Meadows,' *Jour. Agric. Science*, vol. ii., p. 283.

In Hall and Russell's investigations Agrostis and Holcus might on occasion each exceed 20 per cent., and it is stated that 'Wherever *Holcus lanatus* occurs it is more abundant on the fatting fields.' Even miscellaneous herbage could bulk over 29 per cent. on a pasture so good that it could fatten five bullocks on four acres without cake. Armstrong found in a field representative of 'the richest type of old grazing land found in the Market Harborough district' that, amongst grasses, *Poa annua* came second (12·3 per cent.) in point of abundance; while in two meadows, also in Leicestershire, the one representative of 'the choicest meadow land of the neighbourhood,' and the other 'a meadow of above the average quality,' the grasses were 41·5 per cent. and 70·3 per cent. respectively, in the second case Agrostis amounting to 12·7 per cent. There will be general agreement in this audience that four of the grasses just mentioned, Fiorin, Yorkshire Fog, Squirrel Tail, and Hassock are accounted 'bad,' and yet it is hard to apply this term to plants which are the most abundant constituents of some of the finest pastures in England. While there is much that is disconcerting in these investigations, some facts do emerge with satisfactory consistency, (1) that the great majority of high-class pastures contain a large proportion of perennial ryegrass and white clover, (2) that crested dogstail is almost always present though rarely predominant, (3) that meadow fescue is practically negligible, and (4) that of the two Poas, pratensis and trivialis, the former is very rare, while the latter is very common.

The obvious deduction to be drawn from these investigations is that the quality of a permanent pasture is only in a minor degree determined by the relative abundance of its constituent plants, or, in the words of Hall and Russell, 'We can only conclude that the feeding value of a pasture is largely independent of the floral type.' Factors of much greater weight are depth and physical character of the soil, soil moisture and temperature, density of the herbage, and the natural or induced composition of the soil as regards plant food, and especially in respect of phosphoric acid.

That much seems to have been proved, but, such proof notwithstanding, I cannot think we are justified in going so far as Carruthers, when he says, 'The composition of the pastures shows the fallacy of seeking in natural pastures the standard for laying down arable land in permanent grass. The adoption of such a standard is to reverse the whole practice and principles of modern farming.'

It seems to me that the lesson that may be learned from a study of the old pastures of England is that we need not include in a seeds mixture for permanent purposes plants which never bulk to any considerable extent in old grass land, but that we should include all of those which are usually naturally abundant. Take, as an illustration, the case of perennial ryegrass. In the eighties of last century, when much interest was taken in the subject of the best way to lay down land to grass, an almost violent controversy arose over the desirability or otherwise of including perennial ryegrass in a seeds mixture for permanent pasture. The main opponents of ryegrass were Faunce de Laune and Carruthers, who would have excluded this species under all circumstances. The work of Lawes, published under the title 'The History of a Field newly laid down to permanent grass,'[5] also tells against ryegrass, though it is to be noted that the field in question, sown down in 1859, was mowed every year, and there is some reason to believe that this grass is more persistent in a pasture than in a meadow.[6] On the other hand, we have the evidence of a series of experiments laid down by myself in Huntingdonshire in 1900 and reported on in 1905 by Biffen[7] and Middleton,[8] which shows that under certain

[5] *Jour. Roy. Agric. Soc. Engl.* 1889, p. 1.

[6] R. G. Stapledon and T. J. Jenkin, 'Pasture Problems'; *Jour. Agric. Science*, vol. viii., p. 53.

[7] Cambridge University Department of Agriculture Guide to Experiments, 1907, p. 104.

[8] T. H. Middleton, 'The Formation of Permanent Pastures,' *Jour. Board of Agric.*, vol. xii., pp. 385 and 449.

circumstances (in this case Oxford clay) perennial ryegrass does maintain and even improve its position. It is, however, a common experience of those who have laid land away to grass with ordinary commercial seed that perennial ryegrass does not persist,[9] but neither, for the matter of that, does white clover. And the probability is that the cause in both cases is to be found in the same direction. Both these plants, as usually grown in this and other countries for seed, are the progeny of a long line of cultivated ancestors, grown under somewhat forcing conditions which may be said to undermine the 'constitution.' They have adapted themselves to their artificial environment, and such adaptation has taken the form of early maturity and the production of a large yield of 'bold' seed which is easily marketed. Gilchrist has, of late years, directed attention to the merits of wild white clover,[10] which, as regards persistency, is on an altogether different plane from the cultivated or Dutch white. The price that farmers are willing to pay for the seed of wild white clover is the best proof of the sharp distinction which they draw between the two varieties. What we now want is similar work on grasses, and particularly on perennial ryegrass, and it is satisfactory to know that such work has actually been started.

Other lines of investigation associated with the creation of permanent pasture that might repay research are the relative nutritive values of the more important pasture plants when grown under precisely similar conditions, as also under conditions of soil and climate with which they are naturally associated, and when subjected to the actual process of grazing. In 1853 Way published an account of his analysis of grasses, clovers, and other pasture plants,[11] a line of inquiry that was again followed by Voelcker[12] some thirty years later. In the former case the plants were collected as they grew naturally in the field, while in the latter they were specially grown in plots. A comparison of the two sets of figures does not reveal any consistent agreement, a result that seems to support the view that, in respect of nutritive value and mineral contents, grasses are very sensitive to soil conditions and other factors of the situation. The difficulty of determining the feeding value of pasture by means of chemical analysis was experienced in a marked degree by Hall and Russell, who thus express themselves[13]: 'The only general conclusion one can draw is that the method of food analysis as ordinarily practised gives no measure of the feeding value of such material as grass. It fails to reveal anything to correspond to the very marked differences in habit of the fatting and non-fatting grasses, and none of the results can be interpreted so as to show which of the grasses were poor and which valuable food. . . . Although the difference in feeding value was known to be great, the differences revealed by the ordinary methods of chemical analysis were very small. The ordinary methods are clearly inadequate for dealing with pasture grasses.' It would therefore appear that if further attempts are to be made with a view to differentiating between the various pasture plants in respect of nutritive value, resort will have to be had to the digestive track of animals on lines suggested by the Tree Field Experiments at Cockle Park. Areas large enough to provide grazing for a sufficient number of sheep, and, *a fortiori*, of cattle, present a serious difficulty, and the idea suggests itself that perhaps guinea-pigs or rabbits could be utilised as the medium in small-scale experiments. I should also like to see a test made of the effects of sowing the mixed seed derived from the herbage of good grass land fortified with a pound per acre of the seed of wild white clover, in contrast with a mixture of seeds compounded on the most so-called scientific principles. Nearly twenty years ago I took over a heavy farm on the Weald and created as good pastures as, I believe, the land could carry by applying 7 cwt. of basic slag to the foul stubbles without the addition of any seed whatever. I have seen a field of excellent pasture so uniform throughout that no one in a company of farmers and scientific agriculturists could tell any difference between one side and the other, and yet one part of the field was seeded with the most perfect mixture which a leading seedsman could devise, while the other part got no seed at all. The whole field, however, had been well dressed with basic slag. I have still a vivid recollection of sowing down 46 acres to grass in the spring of 1901 on the University Farm at Cambridge. The seed [14] was put in with a thin cover crop of peas and oats, and the weather subsequently proving extremely unsuitable for germination and growth. In July the whole area was a mass of weeds, and few, if any, of the grass and clover plants introduced as seed had persisted. A more derelict-looking piece of ground it would be hard to imagine, and the mowing machine was run over it to clear up the rubbish. But from such an unpromising beginning an excellent pasture has resulted, in my opinion phosphatic manuring, not the primary seeding, being the determining factor.

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[9] Stapledon and Jenkin, *op. cit.*, p. 26.

[10] D. A. Gilchrist, 'Trials of Wild White Clover.' *Jour. Board of Agric.*, vol. xxii.

[11] J. Thomas Way, 'On the relative Nutritive and Fattening Properties of different Natural and Artificial Grasses,' *Jour. Roy. Agric. Soc. Engl.*, vol. xiv., p. 171.

[12] M. J. Sutton, 'Permanent Temporary Pastures,' 1st Ed., 1886.

[13] *Op. cit.*, pp. 369 and 370.

These are the kind of results that cause one 'furiously to think' whether it is not worth while to investigate along the lines indicated, even if these appear to conflict with conventional practice. For this suggestion I hope I may claim the support of Stapledon and Jenkin, who say, in connection with white clover, 'On many types [of soil] phosphatic manure [is] all that is necessary to hasten the appearance of the indigenous plant,' and, further, 'Undoubtedly when putting land down to long duration grass as much or more can be done by making the habitat as suitable as possible to the desirable indigenous species, as by including their commercial counterparts in the mixture.' [15]

Important as is the position of the fine old pastures of England in the agricultural economy of the country, and interesting though it may be to examine questions of seeding, a much more important line of inquiry is opened up by the problem of the improvement of our second- and third-rate pastures. What proportion of the grass land of the country falls into the lower categories it is impossible to say, but the most superficial acquaintance with rural England is sufficient to carry conviction that the aggregate area of such land is enormous. Most of the poor grass land of the country is associated with the heavier classes of soil, and has been abandoned to grass on account of the high costs of cultivation, including, in many cases, the necessity of drainage. It is, for arable purposes, essentially wheat land, with an occasional crop of beans, and the regular intervention at comparatively short intervals of a bare fallow. Other areas of poor pasture, smaller in aggregate extent than the clays, but still of much importance, are to be found on all the geological formations of the country. Of the 14½ million acres of permanent grass in England and Wales, 70 per cent. is under pasture and only 30 per cent. under hay, and of the poorer classes of grass land it is certain that the proportion that is grazed is still greater. It is evident therefore that the improvement of pasture is relatively a more urgent matter than the improvement of meadows, though with over 4¼ million acres of permanent grass made into hay in England and Wales during 1918, the latter problem is also one of enormous importance. The most famous experiments on the effects of manure on permanent hay are those started in 1856 by Lawes and Gilbert on the Meadow at Rothamsted, and continued ever since on the lines originally laid down. The results have thrown a flood of light on the principles of manuring, which has been of the greatest assistance in the elucidation of problems in agricultural chemistry and soil physics. They have also shown unmistakably the effects of the more important elements of plant food on the yield of hay and on its botanical composition, but even supported as they were by elaborate chemical analysis of the produce, they leave us uncertain in regard to the feeding value of the herbage.

A very large number of experiments have been carried out which had for their object the determination of the quantitative results attributable to the use of manures, singly and in combination. In many cases these experiments were supported by a botanical and not infrequently by a chemical analysis of

[14] Cambridge University, 'Guide to Experiments at Burgoyne's (University) Farm,' 1906, p. 72.

[15] *Op. cit.*, pp. 61-62.

the resultant herbage, but it was felt that we were still in a state of much uncertainty in respect of the quality of the hay, that is to say, its effect on animals consuming it. This induced Middleton[16] in the winter of 1900-1 to carry out a feeding experiment with sheep at Cockle Park, and in 1905-6 and 1907-8 Gilchrist[17] continued and amplified this work. The sheep were accommodated in a special house. The various lots of sheep all got equal quantities of roots, cake, and hay. The hay employed was the produce of variously manured plots on old grass land which I laid out in 1897. The soil is a clay loam on a boulder clay subsoil. This set of experiments includes the eight-plot test, and it may be interesting to see what influence nitrogen, phosphoric acid, and potash respectively have on the produce. The quantitative figures refer to the average annual yield for 21 years, 1897-1917, while the figures which indicate the relative values of the produce, as determined by the live weight increase of sheep, are based upon the feeding tests already specified. The hay from the unmanured plot, No. 6, is assumed to be worth 4*l*. per ton. The results are set out in the accompanying table.

| Plot | Manuring per acre per annum | Average Annual Yield of Hay | Value per Ton of Hay as determined by feeding |
|---|---|---|---|
| | | cwt. | |
| 6 | Unmanured . . . . . | 19¼ | 80/- |
| 7 | 30 lb. N in Sulphate of Ammonia . | 23 | 72/- |
| 8 | 50 lb. $P_2O_5$ usually in Basic Slag . | 26 | 93/- |
| 9 | 50 lb. $K_2O$ in Muriate of Potash . | 16 | 80/- |
| 10 | 30 lb. N+50 lb. $P_2O_5$ . . . | 30¼ | 84/- |
| 11 | 30 lb. N+50 lb. $K_2O$ . . . | 21 | 72/- |
| 12 | 50 lb. $P_2O_5$+50 lb. $K_2O$ . . | 26 | 101/9 |
| 13 | 30 lb. N+50 lb. $P_2O_5$+50 lb. $K_2O$ . | 30½ | 89/2 |

Nitrogen derived from sulphate of ammonia, and used at the rate of 30 lb. per acre per annum, has consistently increased the yield and as consistently reduced the quality. When used alone the nitrogen has increased the crop by 3¾ cwt. per acre, and reduced the feeding value of the hay by 8*s*. per ton. When added to phosphates the nitrogen has increased the yield by 4¼ cwt. and reduced the quality by 9*s*. per ton. When nitrogen was added to potash the yield has been raised by 5 cwt. per acre, and the value lowered by 8*s*. per ton. When used as an addition to both phosphates and potash the nitrogen has increased the yield by 4½ cwt. per acre, while the value has fallen by 12*s*. 7*d*. per ton. Even if the quality of the hay be disregarded, the use of nitrogen has always been attended by an adverse financial balance; when quality is taken into account this undesirable result is greatly emphasised.

As regards phosphoric acid, an increased yield has been consistently obtained by its use, accompanied in every case by a marked improvement in the quality of the hay. Taking the arithmetical mean, the increase in quantity has been nearly 8½ cwt. per acre, while the increase in quality is represented by 16*s*. per ton.

The behaviour of potash is rather peculiar. It has quite distinctly reduced the yield when used alone or when used in combination with nitrogen only, while under both these sets of circumstances it has had no influence one way or other on the quality of the hay. When added to phosphates it has proved powerless to increase the yield, but it has raised the feeding value of the hay by 8*s*. 9*d*. per ton. When added to both nitrogen and phosphates the potash has been practically inoperative so far as yield is concerned, but it has improved the quality by 5*s*. 2*d*. per ton.

These results show that very erroneous conclusions may be reached if, in experimental work on meadow hay, attention is only given to the weights of produce secured. Thus, in these Cockle Park experiments, on the average of 21 years, if quantity alone be regarded, sulphate of ammonia used by itself has involved an annual loss of 6*s.* 4*d.* per acre, whereas, if the reduced quality of the hay be taken into account, the loss is increased to 15*s.* 7*d.* per acre. On the other hand, a quantitative gain of 4*s.* 2*d.* per acre per annum from the use of phosphate and potash is raised to one of 32*s.* 5*d.* owing to the superior quality of the hay. While there is a certain relationship between the chemical composition, the botanical analysis and the feeding value of the hay there will probably be general agreement with Middleton when he says that 'Without an appeal to the animal the relative values of samples grown under different treatment cannot be measured.' In my view this form of research may, with advantage, be largely extended.

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[16] *Sixth Annual Report on Experiments . . . at Cockle Park*, 1902, p. 19.

[17] *Bulletin No. 8 of Northumberland Education Committee*, 1906, p. 69; and *Guide to Experiments at Cockle Park for* 1916, p 30

It is unnecessary to attempt to abstract the numerous permanent hay experiments which have been a prominent feature of field-plot trials, especially during the past thirty years. These show unmistakably that farmers of meadow land have an attractive opportunity for the judicious expenditure of capital on artificial manures. It is an opportunity which most progressive farmers have embraced, though the condition of wide areas of meadow land shows how much still remains to be accomplished. Broadly speaking, phosphates are the foundation on which manurial improvement is most surely laid, supplemented in most cases by nitrogen, and in many cases by potash. There are numerous instances throughout the country of phosphates alone producing the maximum return in profit and quality, and sometimes even in weight. Thus on a field in East Suffolk, 'of very poor, heavy land that had been untenanted for some years at Rendham and apparently grew nothing but wild carrots and a little rough grass,'[18] quarter-acre plots were laid down in the autumn of 1900. 'The hay crop of 1901 was so poor that it was not considered worth weighing.' But in the subsequent five years the results were very remarkable, the average yield on the unmanured area being 8 cwt. of hay, as contrasted with 35 cwt. on the plot which received a single dressing of 10 cwt. of basic slag. Taking hay at 2*l.* per ton, and therefore making no allowance for the superior quality of the produce, or for residues, the slag gave a return, after deducting its cost, of 12*l.* per acre.[19] But the apparent lack of the need of phosphates for support from added nitrogen is usually associated with the earlier years of such experiments, and such need disappears later. Hall accounts for the superior early action of the phosphate as follows: 'It is not uncommon to find cases where the application to grass land of a phosphatic manure, like super-phosphate or basic slag, is followed by a great increase of crop, the addition of the phosphoric acid to the dormant nitrogen and potash in the soil having supplied the missing element in a complete plant food. . . . A nitrogenous manure alone is often thought exhausting, but probably a phosphatic manure used singly will even more quickly impoverish the soil.'[20] I agree that this argument applies to tillage land growing non-leguminous crops, but it seems to be put too strongly in the case of permanent grass land. In my view the more marked effects of phosphates in the earlier years is due to the fact that when one applies phosphates one is indirectly applying nitrogen as well. But after the first great flush of clovers, and of Leguminosæ generally, this class of plant becomes less abundant, and consequently the fixation of atmospheric nitrogen by the herbage is reduced, and the crop requires and responds to nitrogenous manures. Where, however, there are abundant natural supplies of potash in the soil the stage of marked reduction in fertility of a hay field may be long delayed. Thus on Palace Leas, at Cockle Park, the plot which for over twenty years has annually received nothing but phosphates is showing a larger increase in the hay crop on the average of the last five years than it did on the average of the first five. And not only so, but the addition of sulphate of ammonia had distinctly more influence in the first five than in the last five years, and this not only when used alone, but also when it was added to phosphates only, to potash only, or to phosphates plus potash. It would appear, therefore, that here at least—and there must be many other instances—the persistent use of phosphates has not only *not* tended to exhaust the soil of nitrogen, but has positively increased it. By way of measuring the extent of the stored-up fertility in grass land that has been treated with phosphates, I carried out a series of pot experiments on the following lines: Five lots of soil and turf from treated and untreated land from the same fields were placed in pots in which five crops of cereals and mustard were subsequently grown, when it was found that on the average the yield was increased by 27 per cent. This result was quite in conformity with the increase of nitrogen in the soil as disclosed by chemical analysis.[21]

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[18] *Report, East Suffolk County Council*, 'Field Experiments, How very poor heavy land Pasture may be improved.'

[19] Cambridge University Department of Agriculture, 'Guide to Experiments,' 1907, p. 150.

[20] A. D. Hall, 'The Manuring of Grass Land,' *Jour. Roy. Agric. Soc. Engl.*, 1903, p. 76.

Turning now to the improvement of pastures, as contrasted with meadows, it may be remarked that while no sharp line can be drawn between these two classes of grass land in respect of ameliorative treatment, there are certain distinctions which must be kept in view. In a meadow the plants are allowed to grow up to full maturity, whereas in a pasture they are cut over daily, or at least very frequently, by the grazing of the animals. It is difficult to arrive at a decision as to whether a larger gross weight of dry material is got from a given area treated as pasture, in contrast to being hayed, but the probability is that the aggregate quantity is greater. Take the analogy of a patch of lucerne. Cut three or four times in the season it may yield six tons of dry matter per acre, cut once it would certainly yield much less. Or take the case of cocksfoot; this springs so quickly in the aftermath that the foliage may shoot up six inches almost in as many days, whereas there would be no such growth were the hay not cut over. It is a matter of observation, too, how quickly red clover springs up after cutting, and trees and shrubs which may be growing only a few inches annually when unrestrained may send up stool shoots several feet in length if cut over. It is difficult, however, to bring the question to the test of figures. I have tried to do so by cutting over an area at short intervals by means of a lawn mower, but the presence of extraneous matter, especially worm-castings, vitiated the results.

If there is any doubt as to the greater weight of dry matter produced under a system of grazing, there can be none in respect of its digestibility. This would appear to be the reason why sheep and cattle will fatten on a pasture, whereas the animals would only remain in store condition on the herbage if made into hay.

At one time experiments on the improvement of pasture took the form of temporarily enclosing an area, to which different methods of treatment were applied and of determining the results in terms of hay. Supplementary to such quantitative determination, chemical analysis and botanical separations were often made, but it is evident from the work of the investigators already quoted that the results so obtained may be a very unreliable index of the feeding value of the herbage. In any case the competition between the various classes of plants may be very different in a hay field and in a well-grazed pasture. Again, in a hay field the produce is reaped and cleared off with all the plant food which it contains. In a pasture, on the other hand, there is the daily conversion of vegetable substance into manure and its immediate return to the land. Reflections of that sort induced me in 1896 to arrange a series of experiments where a direct appeal was made to the animal. We all know that in a lot of animals there are certain individuals which possess idiosyncrasies which result in their thriving better or worse than the others. By careful selection, however, and especially by keeping them under observation for a probationary period, this objection may be largely eliminated. The greater the number of animals the more completely is any disturbance due to individual peculiarities got rid of, and for this reason sheep are usually employed in preference to cattle. No one who looks into the details of these 'manuring for meat' experiments can doubt that, not only in broad outline, but even in the finer details, the results are perfectly reliable. Involving as they do considerable outlay on fencing, water, weighing machines, etc., and necessitating the use of large areas of uniform land, such experiments were not likely to be undertaken with great frequency, but I have been able to find reports of nine in England,[22] twelve in Scotland,[23] two in Ireland,[24] and one in New Zealand.[25] Two of them are situated at Cockle Park, of which the original in Tree Field has now completed its twenty-third season, while the other in Hanging Leaves has a record of sixteen years.

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[21] 'Accumulated fertility in Grass Land in consequence of phosphatic manuring,' *Jour. Board of Agric.*, September 1914 and March 1916.

I propose now to make a brief general survey of the more salient results of this work.

The outstanding feature of these experiments is the great and profitable effect of phosphates. In this material the farmer is placed in possession of an agent of production whose effects on the output of meat, milk, and work from the pastures of this country are only limited by the supplies. In many cases the increase of meat is trebled and even quadrupled, with a return on the original outlay that runs into hundreds per cent. As between the various sources of phosphate there is unmistakable evidence that basic slag is the most effective, not only in respect of aggregate yield of meat, but also, and more particularly, when the net financial return is considered. This conclusion is also reached by Carruthers and Voelcker in a long series of pasture experiments carried out in 1896-9 for the Royal Agricultural Society of England.[26] In these experiments, however, the effects were only estimated by occular inspection. The primary effect of phosphates is due to the marked stimulus that they give to the growth of clovers and other Leguminosæ, and as these plants revel in a non-acid soil the alkaline character of basic slag appears exactly to suit their requirements. It seems highly desirable that a 'manuring for meat' experiment should be conducted with raw phosphates, whose effects on pasture seem distinctly hopeful. Gilchrist dressed a pasture in Northumberland with equal quantities of phosphoric acid derived respectively from basic slag, Belgian and Algerian phosphate, and two and a half years later he reported from occular observation 'that when such mineral phosphates are as finely ground as basic slag the phosphates they contain may be equally effective.' It must be said, however, that this opinion is hardly borne out by the quantitative results obtained on an adjoining meadow where the weight of hay produced by basic slag was distinctly greater than that grown on the plots dressed with the other two phosphates.[27]

In regard to the quantity of phosphatic manure that can most effectively be employed per acre, it would appear that in the case of inferior pasture a heavy initial dressing, say 200 lb. of phosphoric acid or more per acre, is likely to be nearly twice as effective as half this dressing, and therefore actually much more profitable. To secure the best results the Leguminosæ must be rapidly brought up to their maximum vigour, so that they may fully occupy the ground before the grasses have had time to react to the effects of the accumulated nitrogen.

One of the most striking results of these pasture experiments is the long period over which the action of phosphates persists. Even at the end of nine years the meat-producing power of half a ton per acre of basic slag is far from being exhausted. It is not suggested that this persistent action of slag—and no doubt this applies also to any other effective phosphate—is due to unappropriated residues. It is much more probably due to two other causes; (*a*) to the fact that on a pasture in contrast to a meadow manurial elements are kept in circulation from the soil to the plant, and from the plant to the animal, and so, to a large extent, back to the soil again; and (*b*) to the accumulation of nitrogen in the form of humus. Poor unprofitable grass is chiefly associated with clay, and it is fortunate that it is precisely on such land that clover responds so markedly to phosphatic manuring. But conspicuous results have also been obtained on deep peat,[28] on light stony loam,[29] on thin chalk,[30] and on chalk covered by clay with flints.[31] Middleton has very fully discussed the conditions under which phosphatic dressings may be expected to give results [32] and ascribes an important place to soil moisture, on which white clover is directly very dependent. The only conspicuous case of failure of phosphates to improve pasture was encountered in Norfolk, where a 'manuring for mutton' experiment was started in 1901. The soil at that station was a hot dry sandy gravel containing 60 per cent. of sand, and there both basic slag and superphosphate were unable to produce any improvement. Wood and Berry attribute this result partly to the presence of abundant natural supplies of citric soluble phosphoric acid, but chiefly to lack of moisture.[33] In reporting on the R.A.S.E. experiments Carruthers and Voelcker in 1900 had already called attention to the dependence of basic slag on soil moisture.[34].

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[22] 'Guide to Experiments at Cockle Park for 1918' (Bulletin No. 27). *Jour. Bath and West Soc.* 1910. Cambridge Guide to Experiments, 1907. *Supplement No.* 5 *to Jour. Board of Agric.*, 1911. Wakerley, 'Manuring for Milk'; Midland Agricultural and Dairy Institute, 1912.

[23] *Trans. High. and Agric. Soc.* 1905 and 1908. Wright, 6th and 10th Reports on Experiments, West of Scot. Agric. Coll. 1905 and 1911. Greig, *Bulletin No.* 16 *of Aberdeen and North of Scot. Coll. of Agric.*

[24] *Journal of the Department of Agric. for Ireland*, September 1919.

[25] *New Zealand Journal of Agriculture*, 1919, p. 15.

[26] Carruthers and Voelcker, 2nd Report on the Grass Experiments conducted by the Society, *Jour. Roy. Agric. Soc.* 1900, p. 116.

[27] Gilchrist, *Jour. Newcastle Farmers' Club*, 1917.

We may now look at the effect of supplementing phosphates with certain other substances. And, first of all, as regards potash. At most of the manuring-for-mutton stations both in England and Scotland there was a plot devoted to the elucidation of the effect of this substance, and although in the great majority of cases the phosphates-plus-potash plot has shown more live-weight increase than phosphates alone, it is only in very rare instances that the gain has been a profitable one. Even on thin soil overlying chalk potash has had little action on pastures. There are several rather conspicuous instances of quite moderate dressings of potash doing positive harm. Thus, at Cockle Park, whereas potash gave an appreciable increase in live weight in the first nine years, it proved positively and progressively injurious during the next two six-year periods. Even on a 'light stony loam' in Perthshire Wright found that although in the first two years potash when added to slag gave a conspicuous return, in the next three years 'the advantage was wholly with the slag alone plot.' The most notable beneficial effect of potash was obtained in Dumfriesshire on a station where the mineral soil was overlaid by ten feet of peat.[35] There the use of kainit supplying 100 lb. of potash per acre at the beginning of the experiment has in seven years produced 70 per cent. more meat than phosphate (slag) alone, while the financial gain has been improved by nearly 50 per cent.

Potash has had great influence both on the yield and composition of the hay on the meadow at Rothamsted, and it would seem that this substance has more effect on a meadow than on a pasture. The reason is probably to seek in the fact that in a pasture the top layers of the soil are constantly being enriched by the potash brought from the subsoil by plants and returned through their excreta. In any case, pasture plants on clay soil are in possession of abundant supplies of potash, and it is only where pasture occupies sandy, gravelly or peaty soil that this manurial element need be seriously considered.

Lime as an addition to superphosphate was tested at the three original manuring-for-mutton experiment stations, a total of 30 cwt. per acre being applied

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[28] Wright, Report on Experiments on the Improvement of poor permanent pasture by manuring, *Bulletin No.* 54, *West of Scot. Coll. Agri.* 1910, p. 173.

[29] *Ibid.*, p. 187.

[30] Somerville, 'Poverty Botton,' an Experiment in increased Food Production, Miscellaneous Publications of the Board of Agriculture, 1918.

[31] Somerville, 'Influence on the Production of Mutton of Manures applied to Pasture,' *Suppl. Jour. Board of Agric.* 1911, p. 11.

[32] Cambridge University Dept. of Agric., 5*th Annual Report on Experiments*, p. 13; and the 'Improvement of Poor Pastures,' *Jour. Agric. Science*, vol. i., p. 122.

[33] Wood and Berry, 'Soil Analysis as a Guide to the Manurial Treatment of Poor Pastures,' *Jour. Agric. Science*, vol. i., p. 114.

[34] *Op. cit.*, pp. 131-2.

[35] *Bulletin No.* 54 *of the West of Scotland Coll. of Agric.*, 1910.

at Cockle Park and Sevington (Hants) and for eight years at Cransley (Northants). At Cockle Park slag acted substantially better than dissolved bones, though the latter surpassed the effect of superphosphate; at Sevington dissolved bones proved inferior to both the other manures; while at Cransley the position was reversed. But when the cost is considered there is no question of the superior merits of basic slag. This superiority is continued and emphasised at Cockle Park where the experiments are now at the end of their twenty-third year. A similar result was also obtained in the series of pasture experiments conducted by the Royal Agricultural Society of England already referred to. There dissolved bones or bone meal was tried at ten centres, with the result that 'in Herefordshire some benefit was observed, but in the other places no real improvement could be detected as compared with the unmanured part of the field. So far as these investigations go, therefore, they indicate that no further experiments need be made with bones on pasture land.'[40]

With these results before us it is needless to pause to consider whether the comparative failure of bones, dissolved or raw, is due to the inferior quality of their phosphate, or to the fact that they supply the land with nitrogen.

A form of pasture improvement which has had, and still has, much support amongst farmers is feeding with cake. The manure applied to the land through cake residues is a 'general' manure, supplying nitrogen, phosphates, and potash, of which that which has the highest value attached to it is the nitrogen. At eleven of the stations in England and Scotland reported on in the Supplement to the 'Journal of the Board of Agriculture' in 1911,[41] linseed or cotton cake, or a mixture of these cakes, was used for two, four, or five years, and at every one of them the live-weight gain secured was insufficient to pay for the outlay, the debit balance per acre per annum being in one case nearly a pound. In connection with the improvement of pasture, however, it is the residual effect of the cake that has most interest. This matter was put to the test at eight of the manuring-for-mutton stations in the following manner. At the three original stations cake was fed all through the season for two years, and none given for the next four. At five of the other stations cake was fed for two or four years, and was then suspended for one, two, or three years. In this way the improvement of the herbage effected during the years when cake was fed had an opportunity of manifesting itself in the form of live-weight increase in the years immediately succeeding, when no cake was given. In every case the residual effect was found to be appreciable, having a money value per ton of cake consumed of as much as 4*l*. 14*s*. at one station, and 3*l*. 11*s*. at another, the average for the three stations where the residues were followed for four years being fully 3*l*. per ton, a figure which is of the same order as, though somewhat higher than, those adopted by Voelcker and Hall in their revised table of 1902.[42]

At Cockle Park on Tree Field the question of the immediate and residual effects of decorticated cotton cake has been pursued through twenty-one years. After the first stage of nine years, cake was fed for three years, and its residues tested for the succeeding three years, and similarly in the next period of six years. In this connection I cannot do better than quote from Gilchrist's Reports. Commenting on the second six-years period, he says, 'Decorticated cotton cake fed to the sheep on plot 1 in the first three years gave a small gain in these years, but throughout the six years the average annual gain amounts to only 9*d*. an acre.'[43] As to the third period of six years he reports, 'Decorticated cotton cake fed to the sheep on plot 1 in the first three years has resulted in an annual loss of 11*s*. 9*d*. an acre. . . . It is notable that the cake has not given a profitable return from the sheep in the years when it was fed to them, and it has had little unexhausted value in the later years. Nitrogen from the cake has had the same effect on the herbage of this plot as nitrogen from the nitrate of soda on plot 9, and the herbage is still of a coarse and benty character.'[44] This, on land which has had about 2½ tons per acre of a rich cake fed at intervals during twenty-one years is a poor showing, and justifies the conclusion that as an ameliorative agent cake occupies a low position as compared with an effective phosphate like basic slag.

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[40] *Op. cit.*, p. 135.

[41] *Op. cit.*, p. 22.

[42] *Jour. Roy. Agric. Soc. Engl.*, vol. 36, p. 111.

[43] 'Guide to Experiments for 1917,' p. 13.

[44] 'Guide to Experiments for 1918,' p. 15.

A method of improvement of poor pasture that deserves notice consists in scattering the seed of a 'renovating' mixture over the surface, usually with concurrent harrowing, rolling, and manuring. This procedure was practised in the series of experiments conducted by the Royal Agricultural Society of England, the seed mixture consisting of four natural grasses in addition to white clover and yarrow.[45] In their final report Carruthers and Voelcker stated that re-seeding had not been successful, a result which they thought was 'entirely due to the prevalence of dry seasons, the germinating plants being killed before they could get hold of the soil.' A more successful result is reported by Middleton,[46] who on a poor pasture on clay soil in Essex, sowed, in the spring of 1903, 12 lb. per acre of wild white clover seed, with and without basic slag, kainit, and lime, this treatment being unaccompanied by harrowing. There were no Leguminosæ naturally present in the field. Helped by abundant rain in the summer of 1903, when in the London area in June 'rain fell without cessation from midday on the 13th to midnight on the 15th; and at Camden Town the total in fifty-eight hours amounted to nearly 3½ inches,'[47] the seed germinated well, and 'in 1904 the results were very marked.' It was, however, only when the seeding had been accompanied by basic slag that 'there was the luxuriant growth which one expects in pastures where Leguminosæ are present.'

Middleton came to the conclusion that 3 lb. per acre of white clover seed would have been enough, and that ordinary white clover seed, as contrasted with seed from the wild plant, would serve the purpose. Middleton carried out this experiment in the early days of 'wild white,' and probably he would now agree with the suggestion that this variety possesses properties which mark it off rather sharply from the cultivated variety, and that the two, for permanent purposes, are not interchangeable. I also have reported on an experiment where renovating a thin poor pasture with 6 lb. per acre of wild white clover seed was entirely successful, and here, too, the beneficial effects were only secured in the presence of basic slag.[48]

It would appear, therefore, that where the herbage of a pasture is thin, so as to permit of a considerable proportion of the seed reaching the soil, and especially in the absence of natural Leguminosæ, renovation through the agency of wild white clover seed, with concurrent phosphatic manuring, is likely to be successful. Drought, however, at a critical stage of the growth of the young plants may prove fatal, but such a contingency will be best avoided by seeding in early autumn rather than in spring.

The many experiments, and ordinary farming experience, show clearly how poor pastures may be profitably improved in the first instance, but an important matter still remains to be discussed—namely, the means to be adopted to maintain the improvement.

When a responsive pasture is treated, for the first time, with say half a ton of basic slag per acre, the effects reach their maximum usually in the third season. From then onwards there is a steady diminution in the yield, though even after nine years from the time of the initial dressing the improvement is far from being exhausted. At Cockle Park, for instance, the plot dressed once with half a ton of slag was, at the end of nine years, producing three times as much mutton as the continuously unmanured ground, while at Sevington and Cransley the yield, at the end of nine and eight years respectively, was 70 to 80 per cent. greater. None of the other stations was carried on for so long a period, but up to the end of the sixth year most of them show residual fertility which is as great as the original rental value of the land.[49] That is a very important result, but in the interests of the country it is still more important to endeavour to secure that the level reached at the period of maximum productivity shall be maintained.

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[45] *Jour. R.A.S.E.*, 1898, p. 148.
[46] *Jour. Agric. Science*, vol. i., p. 136.
[47] *Ibid.*, 1913, p. 415.
[48] 'Poverty Bottom,' p. 6.
[49] *Supplement No. 5 to Jour. Board of Agric.*, 1911, p. 28.

Some information on this point is furnished by the three manuring-for-mutton stations at Cockle Park, Sevington, and Cransley. At each of these places a plot was dressed with 100 lb. of phosphoric acid derived from slag, and for the fourth season thereafter the dressing was repeated, nothing more being applied for the succeeding six years. At each of the stations there was an immediate response; at Cockle Park the repeated dose acted considerably better than the first; at Cransley the effects of the two dressings were practically identical, only at Sevington was the effect of the first dressing considerably better than that of the second.[50] This subject can be followed for twenty-one years at Cockle Park, where, since the end of the ninth year, 10 cwt. per acre slag (200 lb. $P_2O_5$) are applied every six years to Plot 3, as contrasted with 5 cwt. (100 lb. $P_2O_5$) every three years to Plot 4, another plot receiving at the same time 100 lb. $P_2O_5$ in the form of 7 cwt. of superphosphate. The information we want is as to whether these dressings of phosphates have been able to maintain the high state of productiveness which we know was secured by the initial doses of these substances. The figures bearing on this point are brought together in the accompanying table.

Average annual Live-Weight increase per acre for the same 3-year periods.

| —— | No Manure | 5 cwt. Slag every 3 years[51] | | 7 cwt. Super. every 3 years[51] | |
|---|---|---|---|---|---|
| | Actual Increase | Actual Increase | Gain due to Slag | Actual Increase | Gain due to Super. |
| | lb. L.W. | lb. L.W. | lb. L.W. | lb. L.W. | lb. L.W. |
| 1st dose of manure . | 46 | 90 | 44 | 88 | 42 |
| 2nd ,, . | 36 | 131 | 95 | 126 | 90 |
| 3rd ,, . | 23 | 115 | 92 | 106 | 83 |
| 4th ,, . | 24 | 86 | 62 | 98 | 74 |
| 5th ,, . | 20 | 98 | 78 | 103 | 83 |
| 6th ,, . | 23 | 108 | 85 | 101 | 78 |

Average annual Live-Weight increase per acre for the same 6-year periods.

| —— | No Manure | 10 cwt. Slag every 6 years[52] | |
|---|---|---|---|
| | Actual Increase | Actual Increase | Gain due to Slag |
| | lb. L.W. | lb. L.W. | lb. L.W. |
| 1st dose of manure . . | 41 | 137 | 96 |
| 2nd ,, . . | 23 | 117 | 94 |
| 3rd ,, . . | 22 | 112 | 90 |

It will be seen, in the first place, that the production of the unmanured plot has manifestly declined from the earlier years, a result partly due to the lighter stocking and partly to the shorter grazing season. Confining attention for the moment to the left-hand section of the table, it may at once be said that the high level of productivity induced by the second dressings both of slag (5 cwt.) and superphosphate (7 cwt.) has not been maintained, the cause being probably due, in large part, to a six-year interval occurring between the second and third doses. But there is a distinct tendency for the live-weight increase to rise in the later stages, and, on the whole, it may be said to be conclusively demonstrated that on this particular class of land fertility has been well maintained by moderate dressings of slag or superphosphate at three-year intervals.

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[50] *Supplement No. 5 to Journ. Board of Agric.*, 1911, p. 36.

[51] The 5 cwt. slag and 7 cwt. super. were applied every 3rd year, except that there was an interval of 6 years between the 2nd and 3rd doses.

[52] The slag was applied every 6th year, except that there was an interval of 9 years between the 1st and 2nd doses.

As regards the larger dressing of slag (lower section of table) it will be seen that here also absolute productivity is not maintained at the high level of the earlier years, though as between the ninth and fifteenth years the reduction is very slight. But comparing the production on the manured and unmanured land it will be seen that in these three tests the proportionate increase of meat as a result of repeated doses of phosphates is actually greater at the end of 21 years than it was in the beginning, the ratio rising from 2·3 :1 to 4·1 :1. In other words, for every pound of meat produced on the unmanured land 5 lb. are being produced on the manured ground, and not only so, but the enhanced production is being secured at a cost which leaves a very large profit on the improvement.

The power of repeated moderate dressings of slag to maintain the improvement produced by a large initial dressing of this substance is well illustrated in another series of experiments commenced at Cockle Park in 1903. A field (Hanging Leaves) of poor pasture on clay was equally treated in 1898 with about 6 cwt. of slag per acre. No further treatment was given till 1903 when 4 plots, each 10·1 acres in extent, were fenced off, and to all of them 10 cwt. per acre of slag was given. Since that time a supplementary dressing of 5 cwt. per acre of slag has been given to Plot 1 every 3 years, with the result that at the end of 15 years of this treatment the production of live-weight increase (in this case both cattle and sheep) is nearly as high (200 lb. per acre, average 3 years 1915-17) as at the stage of maximum production (206 lb. per acre, 1906-8). Here, as on Tree Field, under the influence of slag the meat produced is nearly five times as great as on the untreated ground.[53]

Another plot, No. 2, is concerned with the question as to whether cake can be profitably fed to cattle and sheep on land which has first been graded up with a liberal dressing of basic slag. Both Plots 1 and 2 have had the same amount of basic slag since 1898 (36 cwt. per acre) applied at the same time, the only difference in the treatment being that the stock on Plot 2 have since 1904 consumed 3 cwt. of rough cotton cake per acre, except in 1917 when a mixture of palm-kernel and earth-nut cakes was substituted. The quantity consumed up to the end of 1917 is thus practically 2 tons per acre. The cake has in the aggregate in 14 years added about 470 lb. to the live-weight increase per acre produced by slag alone. This increase at present-day rates is valued at less than 9*l.*, to secure which the expenditure on cake is estimated at about 26*l.*, so that the direct and indirect effects of the cake have been extremely unprofitable. As a matter of fact, whereas slag alone gives an annual profit of more than 2*l.* per acre, the use of cake on slagged land reduces the profit to less than 1*l.* Clearly, therefore, cake-feeding on this class of land, which is receiving basic slag, is not a commercial success.

Another aspect of the same problem is dealt with on Plot 3. Both this plot and No. 1 received the same initial dressing of slag—namely, ½ ton per acre for 1903—the differential treatment since that year consisting in No. 1 receiving every 3 years 5 cwt. of slag, whereas No. 3 has had 3 cwt. per acre per annum of rough cotton cake fed upon it. The comparison, in fact, is between the feeding value (indirect) of 5 cwt. of slag and the feeding value (direct and indirect) of 9 cwt. of cotton cake. The results, with those on the other plots, are shown in the table on page 16.

For the first two years, when no supplementary slag had been applied, the cake appeared to give a good account of itself, but the first supplementary dressing of slag distinctly reduced the difference in the two sets of live-weight figures, after which the output of Plot 1 (slag) steadily improved, while that of Plot 3 (cake) as steadily, and more markedly, declined, until in the period 1915-17 the slag was producing 55 lb. per acre per annum more animal increase than the cake. It would appear therefore that the accumulated cake residues have had a positively injurious effect on the pasture, and that this effect is being accentuated as time goes on.

The fourth plot is concerned with the question as to the value of organic nitrogen in fish meal as compared with the nitrogen in cake residues. Plots 2

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[53] Gilchrist, ‘Cockle Park Guide,’ 1919, p. 17.

*Cockle Park, Hanging Leaves Experiment (All Plots received per acre about 6 cwt. Slag for 1898 and 10 cwt. for 1903).*

| — | Plot 1.<br>5 cwt. Slag every 3 years | Plot 2.<br>Same as Plot 1, but also 3 cwt. Cotton Cake fed annually | Plot 3.<br>Same as No. 2, but no Supplementary Slag | Plot 4.<br>Slag (4 cwt.) and Fish Meal (3½ cwt.), supplying $P_2O_5$ and N equal to that contained in the Cake and Supplementary Slag of No. 2 |
|---|---|---|---|---|
| — | Average L.W. gain per acre per annum | Average L.W. gain per acre per annum | Average L.W. gain per acre per annum | Average L.W. gain per acre per annum |
| 1904–5 | 151 | 207 | 204 | 153 |
| 1906–8 | 206 | 251 | 227 | 225 |
| 1909–11 | 187 | 213 | 161 | 187 |
| 1912–14 | 189 | 210 | 150 | 190 |
| 1915–17 | 200 | 227 | 145 | 179 |
| 1918 | 218 | 242 | 142 | 167 |

and 4 got the same initial dressing of slag (10 cwt. per acre) for 1903, since which year the stock grazing on Plot 2 have eaten 3 cwt. per acre per annum of cotton cake. In addition, this plot has every 3 years (commencing with 1906) received 5 cwt. per acre of slag. Plot 4 has every 3 years received 4 cwt. per acre of slag and 3½ cwt. of fish meal, the slag and fish meal combined being estimated to supply $P_2O_5$ and nitrogen equal to these substances contained in the 5 cwt. of slag and 9 cwt. of cotton cake given every 3 years to Plot 2. The cake plot (No. 2) has yielded in the aggregate of 14 years about 470 lb. more live-weight increase, but as the cost of doing so has been about 14*l.* the balance of profit is much in favour of Plot 4. As in the case of Plot 3 (cake alone after initial dressing of slag) the productivity of Plot 4 is distinctly on the down grade, and both as regards the live-weight increase and net returns it compares very unfavourably with Plot 1, which received the same initial treatment as regards slag, and subsequently was dressed at 3-year intervals with 5 cwt. of slag, instead of 4 cwt. of slag and 3½ cwt. of fish meal. It seems to be quite clearly proved, therefore, that on such pasture land as Cockle Park the addition of nitrogen to phosphates is most detrimental, and no doubt for the reason that it encourages grass to the disadvantage of clover.

From this rapid survey of grass-land experiments the following conclusions may legitimately be drawn :—

1. That the quality of a pasture is not primarily dependent on its botanical composition, though, as a rule, the presence of white clover and other Leguminosæ is generally indicative of high feeding value.
2. That poor pastures, especially on clay soil, can be rapidly and profitably improved by the use of phosphates, especially basic slag.
3. That, as a rule, phosphates alone are necessary to effect and maintain the improvement, and that, of supplementary substances, potash and lime are occasionally worthy of attention.
4. That the improvement of poor pasture is very dependent on the presence of Leguminosæ, and especially of white clover.
5. That renovating with the seed of wild white clover may, in the absence of natural Leguminosæ, be a necessary preliminary or concurrent operation.
6. That cake can rarely be used at a profit, and that, as an agent in improving poor pasture, it occupies an unsatisfactory position.
7. That nitrogen, whether in the form of artificial manure, or as cake residues, when added to phosphates for pasture, is always unnecessary and frequently detrimental.
8. That, in the case of hay on permanent grass land, equal weights of produce may have very different feeding values.
9. That few forms of agricultural expenditure are more certain in their results than the judicious use of manures on grass land, and that the meat and milk producing capacity of the country can be largely and rapidly increased, with great pecuniary gain to the farmer, and still greater economic advantage to the nation.

*Spottiswoode, Ballant*

# CO-OPERATION

BY

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*Reprinted from the* "FORTNIGHTLY REVIEW," *April*, 1921

LONDON:
CHAPMAN AND HALL, LIMITED,
11, HENRIETTA STREET, COVENT GARDEN, W.C.2.

# AGRICULTURAL CO-OPERATION.[1]

THE leading characteristic of farming in all modern Western communities is intense individualism. Every farmer wants to cultivate his own bit of land for himself, by his own means, with his own men, and to enjoy the fruits of his own farm: it is an exclusive possession. In Western human nature, at any rate, this love of owning a bit of land and regarding the fruits of that land as essentially your own is a very deep trait, and it is one which is very valuable from the broad political point of view. There is no doubt that the existence of a widespread class of farmers, large and small, each farming, and preferably owning, his own land is a source of great stability to a nation. It is a bulwark against what is to-day rather loosely called Bolshevism, and a safeguard against any Socialistic system of land holding and land cultivation such as State Nationalisation. The farming class is conservative by nature, and, while no doubt it possesses a certain antagonism to progress, it is, after all, a considerable safeguard against hastily conceived changes or ill-considered proposals. One of its chief characteristics is that it does not respond quickly to change, and it is therefore a very good antidote to the more emotional artisan class in the great cities. It should be the aim of statesmanship to preserve this farmer class, with its characteristics of sturdy independence and perhaps undue conservatism, but considerable stability of mind and opinion. Moreover, if the agricultural class, taking it to include all dependent on agriculture who live in the country, are prosperous, well housed, with ample facilities for inter-communication and transport, education, amusement and social life, you have in the nation not only a steadying factor, but a permanent element of happiness and well-being, making for the physical and moral health of the race. That is the first premise with which I start the consideration of agricultural co-operation.

The second is that agriculture is not merely farming—*i.e.*, production—but also a business, an industry. And on its commercial side it has two important aspects. From the national point of view it is desirable that food should be produced at the lowest price to the consumer compatible with a fair profit to the farmer. So far as such an object can be attained by any policy, this should be the object of the politician. But it should also be the farmer's

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(1) An Address delivered on November 15th, 1920, to the Members of the Plough Club, at Wadham College, Oxford, and since revised.

policy. From his point of view it is essential that he should be able to market successfully that which he produces—not only a short crop when the supply is less than the demand, but also a "bumper" crop when the supply tends to exceed the demand. In other words, he should always be stimulating demand; and the best stimulus to demand is a low price. If, then, he is to sell cheaply, it is important to the farmer to be able to get his produce to the man who is going to eat it at the lowest rate of intermediate charges. The cost of production and distribution must be reduced to a minimum.

The second business aspect of agriculture is that England (and any other European country which is not self-supporting as regards its food supply) has to face foreign competition; and it is obvious that in a large number of commodities foreign competition is a factor always of grave importance and sometimes of disastrous power. It was so in the 'eighties and 'nineties, and, in order to overcome foreign competition, the farmer must be able to depend upon a large and regular consumption of his produce at home. In an article like whole milk, which cannot be imported, farmers to-day have an almost complete monopoly; but one day science may overcome that difficulty, and the farmer's monopoly will be gone. And even at the present time he is faced with indirect competition, because in the flush season more milk is produced than in winter, and has to be converted into cheese and other products which can be imported from abroad. In order, therefore, to meet foreign competition, as well as to stimulate the home demand, every single item of cost that can be cut down must be cut down, not only in distribution, but in the cost of all farmers' requirements—feeding-stuffs, fertilisers, machinery, binder twine, and all the odds and ends that are wanted on a farm. The modern farmer's business is to reduce to the minimum the cost of purchasing if he is to sell at the lowest possible price to the consumer and at the same time to get for himself the best margin of profits; and I regard it as a national duty that the farmer, as much as any other producer, should supply the community of this country on as economically cheap terms as are possible consistent with a reasonable profit to himself.

Then there is a political aspect. There is a very large class, many times stronger in voting power than the farmer class, who know little about farming, and who want cheap food at any price. The political outcry for cheap food is one of the most serious factors that agriculture has to face, and is one which it will have to face in an increasing degree during the time that is coming. And if we want to stave off drastic and, to my mind, foolish changes, such as nationalisation of farms, at the demand of a section of the electorate who do not understand farming, we have to bear in mind that farmers must satisfy the broad body of the electorate that they are doing their best to supply food on reasonable terms.

Economic increase of production might be achieved, and is to-day in certain cases being achieved, by means of what are sometimes called "factory" farms. There are a few large limited liability companies, with a substantial capital, owning farms of ten or twenty thousand acres, and farming them as big factories, under managers, on up-to-date lines. In such farms the whole cost of production is being scientifically considered and reduced to a minimum. But, to my mind, that method of reducing the costs of agricultural produce is most undesirable if applied generally throughout the country. It cannot be done without eliminating the small individual farmer, and I think it would be a lamentable disaster to this country if that class, with its independence and all its good qualities, were to disappear. But the process of "factory" farming, of clearing out the independent farmer and doing agricultural business on wholesale lines through skilled men of affairs, is bound to go on unless we have an alternative method which will be equally successful, or nearly so, in its results. We must find some system by which the small man can be preserved and at the same time given the business efficiency and productive power of the factory farmer.

In my opinion there is only one way in which this can be done, and that is by agricultural co-operation. There is no alternative method of business combination possible, in this or in any other country, by which you can preserve all the small independent farmers, small-holders and allotment-holders, each cultivating his own plot, regarding it as his own, proud of it, working late and working hard because it is his own, and because he wants to make the most of it. You cannot preserve that class, whilst giving it the business efficiency which is essential to the profitable conduct of its farms, except by the co-operative system of agriculture.

In Great Britain agricultural co-operative societies are registered under the Industrial and Provident Societies Act instead of under the Companies Act, the former, of course, providing that there shall be no limit on the number of shares. Suppose one hundred farmers start a society and take one hundred shares. Other farmers who join later on come in on the ground floor, so to speak, and get exactly the same conditions as the first farmers. All share alike. All come in on equal terms—an essential of the co-operative movement. Every farmer actually gives up, one may say, a little bit by agreeing that every farmer who comes in shall do so on the same terms in order that he may get the advantage of combination. He does not get the advantage of his shareholding appreciating in value, nor does he get a dividend varying with the profits of the concern; but he gets a fixed rate of interest on his investment, and, if the society makes a profit, he gets at the end of the year a bonus on the trade he has done with the society, which is almost like a share of profits. And, what is far more important, he gets the advantages of commercial combination.

When a farmer wants to buy feeding-stuffs, fertilisers, etc., his society buys them for him, through a skilled manager, at the lowest price compatible with the quality and grade that he is buying, so that he gets a cheap article. The same thing happens when he sells anything to the society. The society gives him a good price for it. Again and again I have known cases where the manager of a society has given a farmer a better price for wheat than he has been able to obtain from the corn merchants of the district. Then there is the advantage which lies in the bargaining power of combination, to which I shall refer later. But the real advantage is not a direct but an indirect one. Under this system, although the farmer nominally buys from the society, technically, and in a legal sense, he is in reality buying through it. For practical purposes the society is his agent, buying the fertilisers, etc., on the best terms that can be got, and, because it is buying not one truckload, but enough to supply all its members for the whole of their requirements, all the members can buy their purchases on wholesale terms. That is one of the biggest points of all in agricultural co-operation: that a large number of farmers, joining together and employing a really skilled manager to do the purchasing for their society, will be able to buy on the most advantageous terms possible. Of course, the buying side of agriculture, looked at broadly, includes importing from abroad and manufacturing, as well as buying from merchants in this country. If agriculture could buy, import and manufacture direct, obviously large economies could be effected, because a certain number of middlemen would be eliminated. For instance, an inter-imperial arrangement, by which co-operators in Great Britain could inter-trade with the big co-operative societies of Australia, New Zealand and South Africa, would bring great mutual advantages. Such a scheme would not be possible for the individual farmer, but it could very well be done by combination through the co-operative system.

Perhaps the best instance of the most advanced point reached by the different kinds of agricultural co-operative societies is to be found in Denmark, where agricultural co-operation has made considerable progress, and has done a great deal. Much has been done, for instance, in standardising and grading Danish butter and bacon, for which there is a special price. It is doubtful if co-operation can go very much further in Denmark. There they have single-purpose societies: the farmer may belong to half a dozen different societies—to a milk, pig, slaughter-house, fertiliser, feeding-stuffs, grain society, and so on. In England it was found that that type of "single-purpose" society did not attract farmers, who, as a rule, prefer one strong society which includes everything, and through which everything in the way of farmers' requirements and produce can be bought and sold. So that to-day there are in England a number of large societies, most of them doing all these things. There are a certain number of dairy societies only, and a few slaughter-house societies, auction marts, and other "single-purpose" concerns, but the tendency is to amalgamate the different types in any area into one large unit with several departments. Nearly all existing societies have been brought or helped into this world by the Agricultural Organisation Society, a purely educational and propagandist body. It was started in 1901 by a group of far-seeing and disinterested men, but at first made slow progress. In 1909, however, the Government gave a small grant, and has continued to do so, from the Development and other Funds—in later years on a much more liberal scale—until the present time. The Development Grant will now run out in about two years, after which the affiliated societies (other than allotments and small-holdings) will have to finance the parent body themselves. The functions of the Agricultural Organisation Society are to advise, supervise, and look after societies, and to see that they carry on business on sound lines. To-day the starting of societies has been nearly accomplished. The Agricultural Organisation Society is a democratic organisation governed entirely by the farmers themselves. It is controlled by a Board of Governors, who are elected by the members of the societies, and it is staffed by skilled experts in different branches of commercial and agricultural organisation; there are milk experts, financial experts, management experts, meat experts, wool experts, and so on. If a society gets into difficulties the Agricultural Organisation Society advises it; they send an expert to inquire into the system of administration, financial position, etc., and help the society to get on its feet again. Broadly speaking, the Government has nothing to do with it, and the whole thing is run by the farmers themselves.

As an instance of a society at its best I will take the Preston Farmers' Society, started in 1903, when a few farmers met together in North Lancashire to form a co-operative society. They did not do much until 1911, but to-day they have 1,551 members, mostly farmers farming less than thirty acres. They have valuable warehouses, plant, motor wagons, horses and lorries for transport purposes, a great number of different depots about the district, and over £80,000 of share capital, and over £80,000 of loan capital, which has all been put up by the farmers. They have an extraordinarily good and efficient staff, who attend all the local markets, and who go round to all the farmers and tell them what the society has done, and can do, for them. The result is that the whole of the farmers in the district trust the society implicitly. They send in their orders for everything without mentioning a price. They simply tell the manager what they want and do not trouble about the price, because they know that they will be charged the lowest that can be charged, usually a good competitive figure on current market prices. At the end of the year they get a dividend on their purchases and sales. That society is a really ideal co-operative society, through which the farmers voluntarily put the whole of their business, and which they do not use merely as a rival trader. They do not get one quotation from it and another from the local merchant, pitting one against the other: they give it their whole business, trusting it completely. As a result the society has a large turnover and can count on a large volume of business. It can buy ahead, because it knows that the farmers will not desert it, and the farmers gain enormously. But to-day there are very few societies doing that; and one nearly always finds that the farmer only half trusts his society.

In some cases societies are formed by amalgamating smaller ones, and so getting additional numbers. The Agricultural Organisation Society is just forming[1] a new society in Cornwall by taking over two well-established merchants' businesses and amalgamating them with some small local societies into one big scheme for the whole of Cornwall. These merchants have agreed to act as local managers in their own district for a long period of years, and, in spite of a great deal of bitter opposition from certain traders in the country, the Cornish scheme ought at once to do business on a really large scale.

Most societies are limited to buying and selling, but amongst other developments are milk products, slaughtering, bacon curing, hiring out of sires, hiring out of agricultural machinery; and much might be done by keeping really good bulls, stallions, etc. The large and well-managed Eastern Counties' Society is developing a very fine seed business, the seeds being grown by the members and tested at their seed-testing station at Ipswich. This is an exceptionally interesting experiment, for, so far, agricultural

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[1] Feb. 1921: now successfully launched.

co-operation has been concerned mostly with the business side of agriculture and not with production. But, personally, I have always taken the view that if you are selling a ton of fertiliser to a farmer you will sell a much more valuable article to him if, at the same time, you sell him the knowledge of how to use it. A good deal of agricultural education of a technical kind and of the best class might be done by utilising the co-operative societies in this way. A man who buys an article, allows the seller to show him how to use it, and realises by results the benefit of using it in that way, will learn a lesson that he will remember. The farmer, in particular, is very much impressed by what he actually sees. He goes to a field, and, seeing that half has been grown with a particular fertiliser and half without, if he sees that one half is 50 per cent. better than the other, he will never forget it. That type of instruction appeals very strongly to him, for with the farmer, more than almost any other class of the community, seeing is believing.

To-day we have the country covered with a series of individual societies in which the ideal is that every farmer should belong to a local society, and at least give that society a business preference. But the individual societies can no more achieve the greatest business success if they stand alone than the individual farmer. As the largest farmers are forced to join hands, so the individual societies will have to join in a central wholesale society. We have now an Agricultural Wholesale Society, of which the individual societies are members, staffed by first-class business men. And the whole strength of the co-operative movement depends upon the strength of the alliance between it and the societies scattered throughout the country, upon the capital they put into it, and the turnover they give it.

Two main difficulties with which the movement is faced to-day are, from without, active opposition by traders and merchants, and, from within, an indifference and lack of appreciation of the economic principles of co-operation which amounts at times to actual disloyalty. Because it runs counter to certain trade interests, the movement is represented by its opponents as a deliberate attack upon all traders in agricultural requirements. This view of agricultural co-operation is an entirely false one. The societies are not antagonistic to traders as such, but it is undeniable that in the past English agriculture has been burdened with a vast number of people who have made a profitable living out of the farmer. There are many middlemen dealing in farmers' requirements who could be done without, and who are effectively done without, under an organised system of agricultural co-operation. A certain number of middlemen will, of course, always be necessary; but at present a perfect chain of dealers and agents, each demanding his profit or commission, stands between the farmer and his original source of supply or ultimate market, as the case may be. It is this waste of time and money that the agricultural co-operative societies are determined to combat. During the last year there have been most vicious attacks on the movement—some of them legitimate, some illegitimate. Rate- and price-cutting, boycotting, orders from the rings not to sell to the co-operative movement, libels in the Press and slanders by word of mouth to an inconceivable extent. The co-operative movement decided that it would sell its wool co-operatively in the London market. Previously it was sold to buyers who came round the country and bought it from the farmers. This year the wool was properly graded and classed, and samples sent up to the London wool market. On the day of the sale the trade arranged amongst themselves to boycott the farmers' wool, so that out of a very large quantity—about seventy thousand fleeces—only a portion could be sold, and that very largely by private treaty. The rest was shunned by the trade. Why? Because the trade knew perfectly well that it had been making a good thing out of the wool, and if it was sold on the market that profit would be lost to them in the future. In the next two or three days much of that wool was sold privately above the reserve price. It was sold to traders who had seen it, and who knew its quality, and who came along quietly to make what they knew was a good bargain. As another instance of trade boycott let me refer to a printed circular which came into my possession from an association who control the whole sale of agricultural machinery in England. It was a direct order to all their agents (and there are 4,000 of them in England) that no sales whatever were to be made to co-operative societies. Again, the Agricultural Wholesale Society are selling meat wholesale at Smithfield for slaughter-house societies, through certain agents, for a low rate of commission under a continuous agreement. The trade at once arranged to tempt some of the societies by offering to take ½ per cent. lower commission than our agents. All this competition is, of course, perfectly legitimate, and helps to prove my main proposition, viz., that co-operation is good business; but it also, on the one hand, shows what tremendous difficulties are facing the movement, and, on the other, that there are many more people living on the agricultural industry than were necessary in the past or can be afforded in the future. Of the illegitimate attacks on us I prefer to say nothing.

The second, and more serious, difficulty lies in the fact that the English farmer has no idea of what combination means. As

I have said, he is very apt to regard his society as a rival trader, or to look upon it as a very useful thermometer by which to test the market. He has a look at the society's thermometer and goes to the merchant on the corn exchange, sees what he can do with him, and, if he can do a halfpenny better, deserts the society, all the time thinking what a sharp man of business he is. As a matter of fact, he is being neither businesslike for himself nor loyal to his friends.

The whole strength of the movement depends on the reality, the extent and the continuity of combined action. In no other way can our farmers achieve the possibility of buying on the best wholesale terms the best quality of all farmers' requirements; by no other road can they reach a position of commercial strength which will enable them to meet the biggest buyers of their produce on equal terms. But the condition of that power is the absolute loyalty of the farmers to the movement and to the wholesale society. And the weakness to-day is that the farmers are often not loyal. It is not that they are wanting in the moral quality of loyalty, but that they cannot see how much it is to their advantage to maintain effective and continuous combination for the sake of the commercial power it would confer upon them. If only societies would delegate to the Agricultural Wholesale Society some definite proportion of their orders and to some extent give up their independent buying; if their managers would not aim at trying to show what clever fellows they are, but trust the Agricultural Wholesale Society to do what, representing all, it could do so much better than they can individually! Once the Wholesale Society is in a position to speak for the whole movement, and holds, as it were, a mandate to buy and sell for farmers all over the country, it can (provided it is adequately capitalised) step into the market and make its own terms. At present, if the Managing Director of the Agricultural Wholesale Society wants to make an arrangement with, say, the X.Y.Z. Fertilisers' Association, they ask what guarantee he can offer that, if the contract is entered upon, the farmers' societies will pass him their orders or any definite proportion of them; and at present the Wholesale Society cannot give that guarantee, because it cannot control its member societies and cannot rely on their business!

This is a very big problem for those of us who genuinely believe that agricultural co-operation alone can save the small farmer. If farmers could only see combination as the Trade Union movement sees it, the problem would be practically solved. There you have a remarkable degree of central control, and confidence in that control, coupled with a willingness to forgo immediate personal advantage and to sink personal feeling for the sake of achieving an end in view. But, so far as the farmer is concerned, the organisation machine is a slow-working machine; slow, because on the one hand it is inconceivably difficult, in commercial matters at any rate, to get farmers to agree quickly and unanimously to any definite course of action, and because, on the other, the Agricultural Wholesale Society cannot act for them, because it has not got the plenary power of acting on their behalf. The farmer is always in a vicious circle. As with turnover, so with capital. He says: "As soon as I see that the wholesale society can do for me all that I want, I will be glad to subscribe the capital." When the Agricultural Wholesale Society replies: "Till we have the capital we cannot do all you want"; he says: "Well, I will wait and see." That is the literal truth, and from that it is easy to see why the progress of agricultural co-operation is slow. But it is making progress; it is gaining strength.

LESLIE SCOTT.